Kennelly Notebook #1

This notebook, which covers the period October 1888-July 1889, is a continuation of N-88-09-28. It contains transcriptions by Arthur E. Kennelly of material from the rough record books used by experimenters in the Galvanometer Room. There are notes, drawings, tables, and calculations regarding a variety of electrical experiments, including tests of meters, octopolar dynamos, galvanometers, phonograph batteries, insulation, and the carrying capacity of various electrical conductors. There are physiological experiments using gasoline on bacteria and earthworms and electrocution experiments witnessed by Edison, Harold P. Brown, and members of the New York State Commission on Humane Capital Punishment. Also included are notes regarding the Brooklyn electrical distribution system; electrical resistance measurements for 39 employees of the laboratory and 220 employees of the Edison Phonograph Works, with information regarding their age, weight, and height; and theoretical notes concerning physics, electricity, and mathematics. Among the experimenters whose work appears in this book are E. C. Boynton, T. F. Lawrence, Theodore Lehmann, and Charles Wirt. At the end of the book is a subject index (filmed at the beginning of the book). The front cover is marked "I" and "1888-1889." The book contains 168 numbered pages. Graphs and other items have been pasted into the book.

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E593.1-1

Record Book

of

Observations, Calculations, and Data in

The Galvanometer Building

Edison Laboratory

Commenced October 20th 1888.

Concluded July 28th 1889.

$$\frac{5.477}{167.5} = 3270 \times 10^{-6}$$

Assuming that $r = a + bt + ct^2$

these observations give

$$145 = a + 5.6b + 33.64c \quad (1)$$

$$96.6 = a + 20.2b + 408.04c \quad (2)$$

$$58.4 = a + 52.2b + 2724.8c \quad (3)$$

Whence

$$a = +170$$

$$b = -4.873$$

$$c = +0.04467$$

Meter Experiments

continued from Record Book no VI page 55.

October 18th Thursday.

Collected 750 c.c. of the last solution (10% by empirical record or 5.5% assumed of $ZnSO_4$ salt) and added 750 c.c. of H_2O distd. thus obtaining a 5% empirical or assumed 2.75% salt solution.

Before dilution the density was observed to be 1.043 @ 19.5°C

after - - - - - - - 1.023 @ 21.0°C by Hyd.

1.025 @ 21.0° . . balance

The tabular density of this solution is 1.014 @ 20°C. so that according to the tables our solution is finally in excess of its estimated strength.

The volume of liquid required to fill the tube was not in this case observed, as it was assumed to be fairly known from foregoing measurements as the following table shews:—

No. of obs.	Date	Method	Deduced Mean Area sq. cms	Estimated Weight of obs.	General Mean	Residual	v^2	Σpv^2	Probable Error
1	10.11	Calipers	5.402	1	5.477	0.135	0.018225	0.02258	± 0.0032
2	12.11	Volumetric	5.467	3		0.010	0.00010		
3	14.11	-	5.484	3		0.007	0.00005		
4	15.11	-	5.420	2		0.057	0.00325		
					5.477 ± 0.003				

The following measurements were made:—

Electrodes 167.5 cms apart.

No. of obs.	Time	Solution	Temp.	Bridge	Mass. thro battery	Mass. thro tube	T.Z. with load	F.Z. 0.3 deducted	t_{20} v.
1	9.35	5%	A 20° B 20.3	1000/1000 1500/1000	1	0.5	2976.7	2972.7	97.2
2	.37	≈ 2.75% $ZnSO_4 + H_2O$		0 . . .	4	2.0	2958.7	2952.7	96.86
3	10.05		A 52.2° B 52.1	- - -	4	2.0	1786.7	1785.7	58.40
4	11.30		A 54° & 62°	- - -	4	2.0	4447.7	4443.7	145.0

Volume Observations

No. obs.	Time	Level in A	Level in B	Sum A+B	Mean Temp	Diff level	Diff temp				
1	9.35	10.2	10.1	20.3	20.2°	4.1	32°				
2	10.05	12.2	12.2	24.4	52.2°	5.0	46.2°				
3	11.30	9.8	9.6	19.4	5.8°						

From this test we have the following observation equations

$$a + 5b + 25c = 34.26 \qquad 5a + 25b + 125c = 171.3$$
$$a + 12.5b + 156.3c = 27.23 \qquad 12.5a + 156.3b + 1953c = 340.4$$
$$a + 16.1b + 259.2c = 24.39 \qquad 16.1a + 259.2b + 4173c = 392.7$$
$$a + 26.4b + 697c = 19.51 \qquad 26.4a + 697.0b + 18400c = 515.0$$
$$a + 32.1b + 1030.4c = 17.52 \qquad 32.1a + 1030.4b + 33076c = 562.3$$
$$a + 39.2b + 1536.6c = 15.61 \qquad 39.2a + 1536.6b + 60236c = 612.0$$
$$a + 45.5b + 2070.3c = 14.00 \qquad 45.5a + 2070.3b + 94196c = 637.0$$
$$a + 52.2b + 2724.8c = 12.88 \qquad 52.2a + 2724.8b + 142237c = 672.2$$

(1) $$5a + 229.1b + 8499.6c = 165.46 \qquad 229.0a + 8499.6b + 354346c = 3902.9 \quad (2)$$

$$25a + 125b + 625c = 856.5$$
$$156.3a + 1953b + 24420c = 42,550$$
$$259.2a + 4173b + 67200c = 63,230$$
$$697.0a + 18400b + 485800c = 13,670.$$
$$1030.4a + 33076b + 1061000c = 18,050.$$
$$1536.6a + 60236b + 2361200c = 23,990.$$
$$2070.3a + 94196b + 4296000c = 28,980.$$
$$2724.8a + 142237b + 7426000c = 35100.$$

(3) $$8499.6a + 354346b + 15712254c = 131,184.5$$

So that the normal equations are

(4) $$8a + 229b + 8500c = 165.4$$
(5) $$229a + 8500b + 354400c = 3903.$$
(6) $$8500a + 354400b + 15,712,250c = 131,155.$$

From (4) $$a = -\frac{229b}{8} - \frac{8500c}{8} + \frac{165.4}{8}$$
$$= -28.63b - 1062.5c + 20.68$$

(5) $$= -229 \times 28.63b - 229 \times 1062.5c + 229 \times 20.68 + 8500b + 354,400c = 3903$$
$$= -6556.3b - 243,312.5c + 4735.7 + 8500b + 354,400c = 3903$$
(7) $$1943.7b + 111,087.5c = -832.7$$

(6) $$= -8500 \times 28.63b - 8500 \times 1062.5c + 8500 \times 20.68 + 354,400b + 15,712,250c = 131,155$$
$$-243,355b - 9,031,250c + 175,780 + 354,400b + 15,712,250c = 131,155$$
(8) $$111,045b + 6,681,000c = -44,625$$

From (7) $$b = -\frac{832.7}{1943.7} - \frac{111,087.5c}{1943.7}$$
(9) $$= -0.4284 - 57.15c$$

From (8) $$111,045 \times -0.4284 - 111,045 \times 57.15c + 6,681,000c = -44,625$$
$$-47,571.7 - 6,346,222c + 6,681,000c = -44,625$$
$$+334,778c = +2,946.7$$
$$c = +0.00880$$

$$b = -0.4284 - 0.5029$$
$$= -0.9313$$

$$229a = 3903 - 354,400 \times 0.0088 + 8500 \times 0.9313$$
$$= 3903 - 3118 + 7916$$
$$= 8701$$
$$a = 37.99$$

Proof. (4) $$8 \times 37.99 + 229 \times -0.9313 + 8500 \times 0.0088$$
$$303.9 - 213.3 + 74.8$$
$$165.4$$

Meter Experiments contd:— (2)

October 14th 1888

Since all the past series of observations with the zinc sulphate tube columns have been taken at or near three temperatures for the sake of a higher degree of accuracy viz— 5°, 20°, & 50° it was judged advisable to take one more series and in this to establish several maxima. At any temperature not a maximum or minimum it is difficult to prevent unequal heating except at the normal temperature, so that to produce more maxima reheating had to be successively adopted.

Took 500 c.c. of the original solution 100% arbitrary) or 55% Zinc assumed of density 1.336 @ 20°C and added 646 c.c. of distilled water to produce 1146 c.c. of 43.6% arbitrary or 24% assumed 2.50 solution tabular density 1.114 g. the observed sp. g: being 1.179 by balance @ 20°C. This solution was chosen because so far as can at present be judged it would be the strength advisable to adopt if the present existing strength of meter solution is to be changed.

Distance between electrodes 167.5. Observations as follows:—

No. of Obs.	Time	Solution	Temp.	Bridge	Resistance	Mag. Res. setting	Max. Res. Index	T. Z. Res. of Cells	T. Z. o.s. deducted	Sp. per.
1	11.50	43.6% ≡ 24% Zn	1 6 / 4.5° 5.5°	1000/1000	·	7	3.5	1049.7	1047.7	34.26
2	12.00		12.4° 12.6°	1000/1000		10	9.1	832.7	832.7	27.23
3	15.22		16.4° 15.8°	-		10	9.1	746.0	745.7	24.39
4	16.27		26.6° 26.2°	-		10	9.1	596.6	596.6	19.51
5	17.05		32.° 32.3°	-		10	9.1	535.7	535.7	17.52
6	17.20		39.° 39.4°	-		10	9.1	477.3	477.2	15.61
7	17.40		45.6° 45.4°	-		10	9.1	428.1	428.1	14.00
8	18.00		52.4° 52.0°	-		10	9.1	394.2	394.0	12.88

Assuming the empirical formula $r = a + bt + ct^2$ where r is the spec. res. of this solution at temp. t°C we have from the observations 1, 4, and 8 the observation equations

(1) $$34.26 = a + 5b + 25c$$
(2) $$19.51 = a + 26.4b + 697c$$
(3) $$12.88 = a + 52.2b + 2724.8c$$

from which

$$a = +38.92 \qquad 38.81 \text{ Dr. Lu.}$$
$$b = -0.978 \qquad -0.1772$$
$$c = +0.00917 \qquad 0.0001444$$

Meter Experiment contd:—
October 19th Friday

In Oxide Researches

To ascertain the effect of mercury alloyed with the zinc in oxidation, took a number of plates of pure zinc containing certain different percentages by weight of mercury in their composition. These plates were supplied by Lehmann under Wilmoski's directions. They were cast in the chemical laboratory from electrolytic zinc and with mercury practically pure. The plates as cast were {10 × 5·3 × 1·15 / 4" × 2" × 7/16"} and were made as follows.

2 plates of pure zinc
2 - - - - containing 1% Hg.
2 - - - - - 2% .
2 - - - - - 3% .
2 - - - - - 4% .
1 - - - - - 5% .

As each pair of plates was received in the Galvanometer Building it was stamped with a die indicating the % Hg. that there might be no subsequent confusion, the impression being made 8 times on each plate.

As these plates were somewhat heavy, they were all cut into quarters breadwise so as to produce 44 plates averaging {5·25 × 2·4 × 1·1 / 2 1/8" × 15/16" × 7/16"} thus exposing some 42·4 sq. cms total surface or when resting on a base vertically 39·6 . . say 40. They were roughly faced with a file and emery-wheel and after being sandpaped were washed in (1) dilute caustic potash and (2) distilled water. After drying, they were weighed by Lawrence. The weights are given below. Two (2,2) of the pure zincs were directly amalgamated to represent actual practice. After the weighing the plates were ranged symmetrically in a large beaker (covered) of meter zinc sulphate solution and set aside to develop oxide.

No. of Plate	% of Hg alloyed	Weight in air	No. of Plate	% of Hg alloyed	Weight in air	No. of Plate	% of Hg alloyed	Weight in air	% Hg	Mean Weight
0_1	0 amalgam	95·4927	4_1	4	97·6410	4_3	4	111·6600	0 am	96·8536
0_2	0 "	98·2144	4_2	4	93·8015	4_4	4	99·0824	0 am	88·0128
0_3	0 —	97·7266	5_1	5	101·2753	5_3	5	102·2170	1	95·1106
0_4	0	88·2990	5_2	5	99·6741	5_4	1	90·8382	2	97·5418
1_1	1	98·9323	1_3	1	92·2777	2_3	2	102·6340	3	97·1610
1_2	1	101·0243	1_4	1	92·4805	3_3	3	90·8365	4	100·5462
2_1	2	96·6619	2_3	2	95·1525				5	101·7221
2_2	2	97·9646	2_4	2	95·2960					
3_1	3	98·3149	3_3	3	98·9040					
3_2	3	101·2780	3_4	3	96·4714					

Zinc Sulphate solution.

Took over charge of manufacture of zinc sulphate solution, zinc plates and phonograph battery solution on 19th October 15 o'clock. Found in stock 5 carboys of solution each containing some 10 gallons, and some 30 lbs. of electrolytic zinc. Shipped 2 carboys to ~~York~~ Rochester same afternoon. Also in stock a barrel of zinc sulphate salt. Samples of this salt were tested on the 20th October and found to contain some iron and traces of arsenic. Decided to make use of this salt after removing the iron. Also made up some concentrated $ZnSO_4$ enough for about 30 gallons from the electrolytic zinc.

Wangemann brought two zinc plates on the morning of the 20th both of which were said to be 10% Hg alloy from the same crucible, and which were certainly used in similar solutions and for equal lengths of time in different cells. One of these zincs produced excessive heat to boiling. The other did not. On examination the former appeared the brighter of the two. Washed them. Specific gravities by Lawrence as follows:—

	In air	In H_2O	sp. gr.
That which did not boil the solution.	239.685	205.242	7.623
- - did - - -	216.278	188.008	7.651

No deduction could therefore be drawn from this source.

The solution in this case and for all the others all being once more 7.5 parts bn. thn. acid, 15. H_2SO_4 Conc. + 40 H_2O

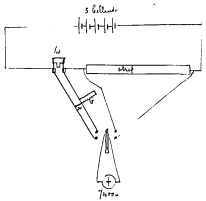
Meter Data supplied by Mr Wirt.

Meter Oxidation as found in practice

From Edgar's letter of May 3rd 88.

Nos	#16	#8	#4	#2	#1
(1) Number of cases	2	4	66	40	25
(2) Maximum	350 mgr.	185 mgr.	145 mgr.	80 mgr.	40 mgr.
(3) Minimum	345	150	50	20	15
(4) Average	348	170	90	48	28
(5) Table	400	200	100	50	25

Line #1 refers to the number of cases tested.
- #2 - - - maximum gain of the pos plate together
- #3 - - - minimum - - - - - - - -
- #4 - - - average - - - - - - - -
- #5 - - - usual no. number given in instruction book.



Meter Tests contd from page 3.
October 19th Friday.

After consultation with Mr Wint, decided to make up a standard meter, using a shunt of 0.1 ω and a resistance coil of about 98 ω.

Made up the coil as follows:—

Bare platinoid wire 0.0145 diam (0.018" # 26 BWG) was wound on a X spool. The ends were clamped under terminals. The resistance of the spool was observed three times.

1st at ordinary temp: 2nd at low temp in refrigerator
3rd - high temp in heater.

No of obs	Time	bridge	Res. std	leads	Res: spool	Temp	Diff Res.	Diff temp	Coeff per °C %
1	Noon	26.3°C 1000/100	98.1ω	0.02	98.12	26°C			
2	13.30	"	98.04	0.22	97.82	12.5°	0.30 (1.24)	13.5°	0.0226
3	14.00	"	99.88	0.22	99.36	90°C	1.54	77.5°	0.0203 } 0.0197

The best value is probably about 0.021 or 0.02 %.

x

The shunt was composed of german silver strip 5.6 cms wide and 0.033 cms thick as used for meters by Bergmann &c: the strip being given us by Mr Wint.

After adjustment, soldering, and fixing in a rough wooden box the res: of the strip was compared with that of a legal ohm and our bridge as follows.

By deflections as in figure: a 100 ω b 900 ω Def on Res: 205.2 On strip 205.2

Temp. legal ohm 22°C.		204.9	203.2
		204.6	203.0
	changed = 100 ω	208.5	205.7
	changed 200 b 1800	207.1	205.6

From best readings the strip $= \frac{1}{10} \times \frac{203.1}{204.75} \times 1.002 = 0.0994$ ω

By bridge 100% T. 25°C. Res: of shunt & leads 0.11852
- - leads 0.02062
0.0979 × 1.002 = 0.09808

Comparison by bridge of legal ohm and shunt.
100,000 ω = 98.57 ω uncorrected for T.B. 21.7°C.

$\frac{98.57}{100} = \frac{7}{1168}$

Res: of shunt and leads 0.11485
- - leads. 0.01932
0.09553

Meter Experiments contd—
October 21st Sunday.

With Mr Wilk aid made up five 25 light meter bottles as follows.

No. of Plate	Observed weight + paper disk	Observed weight of paper disk	Weight of plate	Sum of + and − plates	Observed weight of empty + disk	Weight of empty	Discrepancy	Mean Discrepancy	Adjusted Weights
	0·-	0·7290							
1	90·2210		89·4920	177·4300	178·1589	177·4299	−0·0001		89·4920
2	88·6670		87·9380						87·9380
		0·7290							
3	89·5477		88·8187	178·8687	179·5971	178·8681	−1·0006		88·8185
4	90·7790		90·0500						90·0498
5	85·8046	(assumed at) 0·7293	85·0753	173·0411	173·7693	173·0400	−0·0011	0·0005	85·0749
6	88·6951		87·9658						87·9654
		0·7293							
7	89·5058		88·7795	176·5217	177·2514	176·5221	+0·0004		88·7796
8	88·4715		87·7422						87·7423
9	85·3292		84·5999	173·0056	173·7346	173·9053	−0·0003		84·5998
10	89·1350		88·4057						88·4056

These bottles were labelled & set aside for meter use.

October 22nd Monday.

Repeated observations on the resistance of the shunt for the standard meter. Bridge 1000 : 100 (multiplying power 10) on legal ohm at 23.3°C.

No. of Obs	Res. of Artificial Gold	Res. in art. with Gold	Ratio in Bridge	Temp. of Legal Ohm	Res. of Legal Ohm at	Deflection on Shunt of Artificial Gold	Deflection on Shunt of Legal Ohm for meter Resist.	Mean Ratio	Res. of shunt
1	74·00	25.000	1000:100	23.2°C.	1·003	161·3			
2							158		
3						157·8			
4							156·9		
5					next page	158·8			
6							2·8 156·5	158·5 / 158·15	9.886×10^{-2}
7						158·5			
8							2·1 156·3	156·3 / 158·14	9.896×10^{-2}
9						158·3			
					Mean	158·85	156·93	156·9 / 158·9	9.904×10^{-2}
10			2000 : 200	23.4°	1·003	156·5	155		
11						156·5	155	155 / 157	9.900×10^{-2}
12						157·5			
13						157·0	155		
14									

Mean 9·8965

No. of mean	Result $\times 10^{-2}$	Method obtained	Estimated weight	General Mean	v	v^2	pv^2	Σpv^2	$0.6745\sqrt{\frac{\Sigma pv^2}{p(n-1)}}$
1	9·940	Deflections	3	9·899	0·041	0·001681	0·005043	0·147040	0·041142
2	9·981	Bridge	3		0·082	0·006724	0·020172		
3	9·55	Bridge	1		0·349	0·121801	0·121801		
4	9·897	Deflections	6		0·002	0·000004	0·000024		

Result 9·899 ± 0·041
= 0.0099 ± 0·0004 @ 23°C.
a probable error of 0·4%

Meter Experiments contd —

October 22nd Monday)

Resistance of platinoid spool wire (uncovered) wound on open spool before enclosed in box 98·088 @ 22·°C.

Tested the two 25 light meters as follows — (1) Shunts.

Deflection method.

No of Obs	Res. of Galv.	Res. in at with Galv.	Bridge Ratio on Ib	Temp Legal Ohm	Res. of legal ohm at temp	Deflection on legal ohm reduced to 1 ohm	Deflections on shunts of meter I A	Deflections on shunts of meter I B	Deflections on shunts of meter 2 A	Deflections on shunts of meter 2 B	Temp Meter	Mean Discrepancy
1	74·00	0	9909 : 100	23·5°	1·003	64·0	64·8 64·2	64·5 64·1	64		23°C.	
						63·6	~~64·4~~		64·1	64·0 63·9		
						63·5				63·9		
		From these deflections the mean resistances of the shunts would be:—					0·00104	0·01011	0·01010	0·01016		1·1%
		Resistances of spools by bridge after tightening up screws					8·041	8·121	8·079	8·121		

Placed bottle containing plates 3 + 4, 5 + 6 in meter #2 on a shelf above the steam pipes. Bottle # 1 + 2 was placed in the standard meter on a table in the outer room and bottles # 7 + 8, 9 + 10 were placed in meter #1 lodged in the refrigerator with the thermostat arranged to switch in a lamp at 4°C. All these 3 meters were joined up in series with an ampère-meter and resistance. They were set to work on the 113 volt circ. at 114·49 the current being 3·8 ampères steadily maintained.

Oxide experiment carried out by Lawrence.

Two small widemouthed stoppered glass bottles each holding rather more than 200 c.c. were procured and cleaned. Into bottle #1 cold meter Zn Sol. solution (and poured of density) by balance 1·0603 @ 22·°C. Into the other bottle #2 the solution was poured when hot after having been raised to {82°C (180°F} gradually) in a flask in order to expel the dissolved air. Two zinc plates with the copper rods removed were placed in each bottle. These weights of these plates were as shewn in the following table. The plates were 25 light ones lately amalgamated by Mr Watt, and of bright appearance.

No. of plate	Weight of plate + disk	Weight of disk	Weight of plate	Weight of plain	Weight disk of plain + disk	Observed weight of pair	Discrepancy	Mean Discrepancy
1	81·8852	0·7332	81·1520	162·5138	163·2474	162·5142	+ 0·0004	0·00045
2	82·0950		81·3618					
3	81·8990		80·8658	165·0585	165·7922	165·0590	+ 0·0005	
4	84·9259		84·1927					

Meter Experiments contd :-
October 22nd Monday

With the view of having at command a compensation for the temperature error of the meter solution, took 3 samples of cotton covered iron wire from reels in the stock room and wound them on open wooden X spools. Measured the res: of these at 3 different temperatures. Also repeated the measurement of that sample of nearly pure iron wire brought by Mr Watt the temp: coeff: of which sample came out so low on the 16th inst.

Dimensions

No. of sample.	Length	Condition	Wire diam: inches	B.W.G.	Wire diam: cms.	Areas sq. cms.	Areas / Length.		
1	575	bare	0·035"	20	0·0889	0·006207	1.080×10^{-5}		
2	800	cotton covered	0·022	24	0·0559	0·002456	3.067×10^{-6}		
3	700	" "	0·022	24 weight 25	0·0559	0·002456	3.067×10^{-6}		
4	700	" "	0·012	30	0·0305	0·0007306	1.044×10^{-6}		

Specific Resistance

No. of obs.	Bridge	Res: @ 21° C	Corrected to 0°	Sp. res.	Bridge	Time Ratio	Balance	Res: @ 21° C	sp. res.
1	1000/10	1·057	0·9459	10.2×10^{-6}	1000/100	99·6	1·050	1·0534	1.1383×10^{-6}
2	1000/10	4·817	4·320	13.25×10^{-6}	"		4·791	4·810	14.752×10^{-6}
3	"	4·570	4·211	12.92×10^{-6}	"		4·540	4·560	13.9857×10^{-6}
4	"	1·020	—		"		1·020		

Temperature Coefficient

No. of sample	Temp: in Refrigerator	Res: obtd. lands deducted	Temp: of air	Res: obtd. lands deducted	Temp: of incubator	Res: obtd. lands deducted	coeff: for low to mean temp.	coeff: for mean to high temp.	coeff: for low to high temp.
1	7°	0·979	21°	1·057	118°	1·840	0·53	0·57	0·57
2	7°	4·505	20°	4·817	138°	8·080	0·52	0·44	0·45
3	7°	4·330	21°	4·570	160°	7·900	0·39	0·39	0·39
4	7°	9·260	21°	12·18	103°	17·11	1·98 ?	0·42 / 152 / 145	0·42 ? / 153 / 145

Samples preserved.

Data supplied by Mr Wirt, taken from a paper by W. H. Preece in the Elect: World 17th Sept. 87

@ 60° F Iron's res: to Copper's Res. bears ratio of 6·034
Conductivity 0·982 of Matthiessen's standard
Temp. Coeff 0·48% per °C.

Laboratory Boilers. Boynton observer.

The load on the dynamos and engines reaching daily a maximum shortly before 18 o'clock, measurements were made on October 26th of the coal and water consumed by one Babcock and Wilcox double-furnaced boiler between the hours of 16 and 19 o'clock. During that time both Armington-Simms engines ran and also the Brown Engine. The level was maintained in the gauge, and the fires kept up. The boiler pressure indicated at 16 o'clock was 110 lbs

" " " " " 18 " " 65 "

" " " " " 19 " " 80 "

Steam was supplied to the heating pipes of all the buildings. The measured amount of water consumed was 18,200 lbs.

" " " " coal " " 2224

for 3 hours or per hour av. " " water " " 6070

" " " " " coal " " 741

Since by recent measurements it was found that 5½ lbs of coal and 49⅔ lbs of water were consumed per H.P. hour, the average activity of the boiler was by coal consumption 134

" " water " 122

The mean load on the Day circuit amounts being 225 HP

" " night " " " " 220 "

" " lamp-work " " " 40 "

485 "

The mean electrical load at 115 volts = 75 Elec. HP.

Allowing 16 HP to be supplied by the Brown Engine makes a total of 91 HP actually utilized, leaving 40 HP for heating of the buildings and losses in the dynamo shafting and dynamos.

A number of experiments were made with cylinders of wax and zinc suspended by thread vertically in zinc sulphate solution in the path of an electric current rising as high as 10 amperes with the view of ascertaining whether there were any increased or diminished friction on applying the current. The cylinder was caused to rotate by putting torsion on the thread and the time of one revolution under a certain amount of torsion noted with the current on and off. No difference could be detected. (27th to 30th October)

Tests of new pattern Grenet cell.

3 cells for the phonograph were designed by Mr Ott and were made as follows:—

A glass jar was filled to a convenient level with chromic acid solution. It was supported in a special cast iron stand and was closed by a lid movable up and down on a vertical slide rod fixed in the stand. The lid held a number of carbon rods in two rows clamped at the top & standing vertical, also a single zinc plate midway between and in plane parallel with the rows of carbon rods. By this means both the zinc and the carbons could be raised ~~xxxx~~ together from the solution.

Cell No	Internal Height	Internal Diam.	No. of carbons	Length of carbons	Length of zinc	Breadth of zinc	Thickness of zinc	Distance between zinc & carbons	Weight of zinc	Distance between rows of carbons
1	29	19	18	19.3	20.1	12.6	1.0	1.0	1828	3.3
2	20	16.6	14	20	14	10	1.0	1.0	987	
3	22	14.5	10	20	14	7.5	1.0	1.0	758	

Cell No.	At start			At end of 6th hour			At end of 12th hour			
	EMF	I.R.	C.	EMF	I.R.	C.	EMF	I.R.	C.	Duration of life above 2 amp
1	1.98	0.027	3.736	1.87	0.014	3.4	1.73	0.074	3.014	20.5
2	1.978	0.038	3.676	1.85	0.065	3.3	1.64	0.155	2.504	14
3	1.982	0.049	3.612	1.88	0.075	3.26	1.68	0.168	2.516	15

Corresponding quantities for ordinary Chromic acid cell small size

Cell No										
	2.05	0.10	3.3	1.97	0.11	3.25	1.90	0.28	2.4	13

These cells were set to work each on 0.50 platinoid strand at , having been charged with the usual solution whose formula is 7.5 part Chromic acid 15 part H_2SO_4 and 100 part H_2O. The curve sheet of the plotted observation is preserved. The noticeable feature of these cell is the low EMF due probably to the porosity of the carbons.

Curves of fall in the resistance of a 25 lb. main battery during the steady passage of one milliampère current.

The lines of the battery were at first prepared 1.3. and the fall is about 16 to 2.5 in 14 hours.

Find 4 curves the corresponding plot for a 2 milliampère current on the 1st.

Cover both sets curves corresponding to 4 ma.

Meter Experiments cont'd:—
October 23rd – 25th partly observed by Mr Watt, partly by Mr Hennelly.

A 25 lt meter bottle was taken which had been set up on the 5th inst. (p. 21 VI) when its res. was 1·3 ω, then set aside till the 12th; when a series of measurements was taken of its resistance (p. 48 VI) and since then remained untouched.

No. of Obs.	Date	Time	Time for state	Current	Bridge	Res. T.Z.	Leads	Res. of bottle T.Z.	Temp. bottle
1	88.10.23	15·00·	0·00	1 ma	100/10	16·20	0·22	15·98	23°C
2		·05	0·05			16·10		15·88	
3		·10	0·10			14·60		14·38	
4		·15	0·15			13·50		13·28	
5		·20	0·20			12·70		12·48	22·5°
6		·25	0·25			12·20		11·98	
7		·30	0·30			11·70		11·48	22·5°
8		·35	0·35			11·20		11·05	
9		·40	0·40			11·05		10·83	
10		·45	0·45			10·65		8·43	
11		·50	0·50			10·10		9·88	
12		·55	0·55			9·35		9·13	
13		16·00	1·00			8·85		8·63	
14		·05	1·05			8·20		8·08	
15		·10	1·10			7·80		7·58	
16		·15	1·15			7·35		7·13	
17		·20	1·20			7·05		6·83	
18		·25	1·25			6·85		6·63	
19		·30	1·30			6·65		6·43	
20		·35	1·35			6·45		6·23	
21		·40	1·40			6·25		6·03	22·8°
22		·50	1·50			5·95		5·73	3
23		17·00	2·00			5·70		5·48	
24		·10	2·10			5·50		5·28	
25		·20	2·20			5·35		5·13	
26		·30	2·30			5·20		4·98	
27		·40	2·40			5·10		4·88	
28		·50	2·50			5·00		4·78	
29		18·00	3·00			4·875		4·66	22·8°
30	88.10.24	8·10	17·10			4·60		4·38	18·8°
31	·10.25	9·25	42·25			4·05		3·93	20·6°
32		16·00	49·00			3·20		2·98	21·0°

October 31st Wednesday observed by Mr Lawrence.

Weighed 4 pairs of plates 2 pairs of unvarnished and two pairs of each side varnished plates. 2 bottles raised to 80°C. in sand-bath before immersion, 2 bottles at ord. temp.

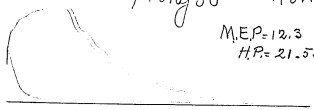
No. of plate	Weight of plate + disk	Weight of paper disk	Weight of plate alone	Sum of couple	Weight of couple + disk	Weight of couple alone	Difference now earth	Condition	Solution
1	88·6470	0·7327	87·9143	175·4118	176·1476	175·4149	+0·0031	plain	heated 100°
2	88·2302		87·4975						
3	87·2363	0·7300	86·5063	175·9096	176·6390	175·9090	−0·0006	plain	normal
4	90·1333	0·7300	89·4033						
5	90·2800	0·7309	89·5491	179·9690	180·7002	179·9693	+0·0003	varnished	heated
6	91·1505	0·7309	90·4199						
7	89·3413	0·7345	88·6068	177·3568	178·0910	177·3565	−0·0003	varnished	normal
8	89·4845	0·7345	88·7500						

N.B. It was noticed after 12 hours that the plates had been warmed were covered on their metallic surfaces with bubbles probably of air, a dense appearing on the varnished surfaces. Plates 1 2 5 + 6 in the solution that 3 4 7 + 8 showed only few or none bubbles

Activity of Engine at Phonograph Factory
November 1st 1888. Mr. Boynton observer.

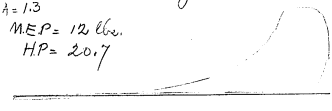
Total H.P. from two diagrams taken at 15 o'clock 44.74 } Mean 43.5
Porter - - - - 15.10 . 42.25 }
Boiler gauge 65 Revolutions 83.
Total H.P. at the corresponding date last month 33.

Rev. 83 Back ~~New Style~~
Pres 60 Time 3 PM
Spring 30 Nov. 1. 88



M.E.P. = 12.3 A = 1.83
H.P. = 21.55

Rev. 83 Front Old Style
Pres. 60 Time 3 P.M. Nov. 1. 88
Spring 40



A = 1.3
M.E.P. = 12 lbs.
HP = 20.7

Meter Experiment contd:—

Sunday 4th November.

Closed the meter test which has been going on since Oct: 21st the current having been passing through them from 7 to 12 and 12·30 to 1 o'clock daily since 14·4·9 22.11.88 see page 7. Removed the plates, dried, and weighed them with following results:—

No. of Plate	Weight of paper	Weight of dried paper	Weight of Plate dried	Sum of coupons	Weight of coupons	Weight of paper dried	Weight of coupons dried	Discrepancy	Probable value of plates dried	Probable value of coupons	Sum as check of probable weights
1	89·4237	0·7349	88·6888	177·4590	178·1945	0·7348	177·4600	+0·0010	88·6891		
2	89·5049	0·7347	88·7702						88·7705	177·4598	177·4596 / ·0397
3			88·0784	178·9166			178·9173	+ 0·0007	88·0786		
4			90·8382						90·8384	178·9171	178·9170 / 176·8861 / ·0289
5			84·3038	173·0845			173·0847	+ 0·0002	84·3039		
6			88·7807						88·7808	173·0846	173·0847 / 173·0840 / ·0007
7			88·0652	176·5623			176·5638	+ 0·0015	88·0657		
8			88·4971						88·4976	176·5633	176·5633 / 176·5231 / ·0277
9			83·8506	173·0618			173·0633	+ 0·0015	83·8511		
10			89·2112						89·2117	173·0628	173·0625 / 173·0021 / ·0890

Comparison of Weights

No. of Plate	Adjusted Weights 27.10.88	Adjusted Weights 4.11.88	Gain	Loss	Corrected Loss for shunt error	Mean Loss	Mean Temp.	Ratio Standard. Mean Loss	Ratio Normal Temp. / Your Temp.	% Error per °C	Mean Temp.
1	89·4220	88·6891		0·8029	0·5109		18°C.				
2	89·5350	88·7705	0·8325 / ·0296								
3	88·8185	88·0786		0·7399							
4	90·0498	90·8384	0·7886 / ·0487			0·7555	24·4°C Mile 42	1·073			
5	85·0749	84·3039		0·7710							
6	87·9654	88·7808	0·8154 / ·0411						1·033	0·19 % / 1% for 5°C	17·4°C
7	88·7796	88·0657		0·7139							
8	87·7423	88·4975	0·7583 / ·0411			0·7313	7·0°C. Mile 81	1·109			
9	84·3398	83·8511		0·7487							
10	88·4056	89·2117	0·8061 / ·0574								

Comparison of oxide &c.

No. of Plate	Gain in excess	Mean Gain in excess		Mean Percentage Loss of oxide with Plate 3 yrs	Mean Percentage loss of oxide with Plate Test 9 yrs	Mean Consequent Loss of bottle 3 yrs	Mean Consequent Loss of bottle Test 9 yrs	Ratio Mean oxide loss / Mean bottle loss	Inverse ratio	Calculated Corresponding Gain of bottle
2	0·0296	0·0296		10·736		(April 6·08.)	(April 7·02.)			(0·974)² = 0·948
4	0·0487	0·0466		10·73	12·09	2·65	3·87	1·347	0·7424	
6	0·04444									
8	0·0411	0·05444		~~10·09~~	~~3·50~~	~~3·00~~				= 10°
10	0·0574									

Meter Experiments contd:—
November 4th Sunday.

The two sealed bottles containing plates without zinc, mentioned on page 7 were unsealed and the plates withdrawn, dried and weighed. These the plates that had been left in bottle #2 containing heated solution had a distinct metallic lustre, while those in bottle 1 were on the contrary dull and oxydised. Results as follow:—

observations by Mr West

No. of plate	Simply	In pairs	Discrepancy	Adjusted value 31.10.88	Adjusted values 31.10.88	Gain	Loss	Loss gram of couple	Ratio of loss gram in tot. gram in cells		
1	81·2305	162·5400	-0·0003	81·2304	81·1519		0·0785				
2	81·3098			81·3097	81·3617	0·0520				Bottle #1 cold solution	
				162·5401	162·5136			0·0265			
3	80·8022	165·0789	-0·0007	80·8024	80·8660	0·0636			79·6	Bottle #2 Heated sol.	
4	84·2774			84·2775	84·1928		0·0847				
				165·0799	165·0588			0·0211	Reduction of 20%		

Judging from the figures which show that two plates have lost and two have gained it would seem that since the plates rested in contact in each bottle local action has taken place.

Two unamalgamated but cleaned zinc plates were immersed in solution that was first raised in the bottle to 84°C by means of a sand bath with the object of ascertaining whether they would throw off bubbles of gas in the same manner derived in the case of amalgamated plates. It was noticed on the following day however that no bubbles had formed but that the plates had become discolored — blackened — superficially. Weights observed by Mr Lawrence 3. 11. 88 before immersion as follows

No.	Weight + dish paper	Weight of paper dish	Weight of plate alone	Sum	Weight of sum + dish	Weight of sum only	Discrepancy	Adjusted weight simply	Adjusted sum		
9	81·9690	0·7350	81·2340	165·1188	165·8540	165·1190	+ 0·0002	81·2341	165·1190		
10	84·6195		83·8848					83·8849			

Bottle labelled and set aside.

Amalgamation measurement by Mr Lawrence.

To determine the change of weight brought about by amalgamation, two fifty-light plates were cleaned by Mr West but not amalgamated 4th Nov. Their weight on the 5th November was taken and they were then dipped in 10% H_2SO_4 for a few moments and amalgamated. The weight after drying were then repeated as follows:—

No. 1. before	176·1900	after amalgamation	176·0410	loss	0·1490
No. 2 .	176·5715	-	- 176·3980	-	0·1735
Mean	176·3808	-	- 176·2195	-	0·1613

In other words the plates seem to have lost more by dipping into the acid than they gained by amalgamation.

Motor Tests continued. Observations chiefly by Mr White.

Resistance of a bottle (25 lb) which had been set up on the 5th inst. and which has since remained untouched.

No.	Date	Time	Time from Start	Current	Bridge	Res TZ	Leads	Res. bottle TZ	Temp bottle		
1	88.11.3	14.05	0.00	2 mar.	not/10	20.90	0.22	20.68	23°C		
2		.10	0.05			18.30		18.08			
3		.15	0.10			15.20		14.98			
4		.20	0.15			12.00		11.78			
5		.25	0.20			10.50		10.28			
6		.32	0.27			9.20		8.98			
7		.55	0.50			7.25		7.03	22.4°		
8		15.00	0.55			7.00		6.78			
9		.10	1.05			6.50		6.28			
10		.21	1.16			6.20		5.98			
11		.30	1.25			5.95		5.73			
12		.45	1.40			5.80		5.58	22.5°		
13		16.00	1.55			5.50		5.28			
14		.30	2.25			5.15		4.93			
15		.40	2.35			5.00		4.78			
16	88.11.4	11.50	21.45			3.55		3.33	20°		
17	.11.5	8.10	22.05			3.40		3.18	13.8°		
18	.11.5	17.10	51.05			2.40		2.18	25.8°		

Transformer Experiments
November 5th Monday

Transformer running, at 1200 volts (approx) and 5.5 amperes on primary = 6500 Watts delivering about 50 amperes at 100 volts on secondary terminals = 5000 Watts. Fields supplied by 150 volt cell. After running for half an hour the highest temp reached by thermometer at armature periphery under cotton waste was 190°F = 88°C.

Meter Experiments continued. Observations by Mr Lawrence
November 5th Monday.

Amalgamated and coated with varnish on back and sides a number of plates to repeat the test of the three meters obtained during the last few days.

No. of Obs.	Weight of plate	Weight of sample	Sum of sample plate	Difference	Adjusted weight of plate	Adjusted weight of sample	Sum on check	Meter
1	87.1979	174.4362	174.4359	+ 0.0003	87.1980	174.4361	174.4361	Standard
2	87.2380				87.2381			
3	87.6246	170.0017	170.0010	+ 0.0007	87.6248	170.0015	170.0014	Meter #2 Normal temp.
4	82.3766				82.3766			
5	89.1536	176.4160	176.4156	+ 0.0004	89.1537	176.4159	176.4158	
6	87.2620				87.2621			
7	88.8450	not matched. Discarded.						
8	86.5613	173.7055	173.7051	+ 0.0004	86.5614	173.7054	173.7053	Meter #1 at low temp.
9	87.1438				87.1439			
10	86.2295	173.9805	173.9802	+ 0.0003	86.2296	173.9804	173.9804	
11	87.7507				87.7507			

Meter set to work at 17.0 o'clock at 3.75 ampere. #1 in the refrigerator and #2 at normal temperature.

Transformer Experiments contd:
November 6th 88.

Plain transformer. Commencing at 11.15

11.20	Volts on primary	1290	ampere	5.6	=	7220 Watt.		
	" " secondary	100	"	44	=	4400 "	60% eff.	90 lamp in cct.
.30	" " primary	1280	"	6.3	=	8060 "		
	" " secondary	99	"	50	=	4950 "	61.4%	108 lamp
.40	" " primary	1300	"	6.4	=	8220 "		
	" " secondary	100	"	49.5	=	4950 "	60.2%	" "

.45 Top carter carried away on transformer shaft and the fuzes of the municipal followed.

The above efficiencies are not very reliable since the Municipal wattmeter readings are at present in question.

On the arrangements necessary to illuminate 15, 60, 120 and 180 lamps from a Brush 30-light arc dynamo intended for 9.6 amperes, at 750 revolutions per minute.

Each municipal lamp of 20 cp has 6.6 ohms and needs 3.2 ampere or 21.1 volts.

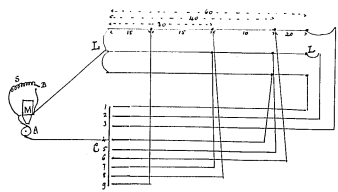
To light 180, 3 series of 60 lamps in parallel, voltage 1270, or 1373 at brushes with 9.6 amperes.

To light 120, 3 series of 40 lamps in parallel, voltage 845, or 900 at brushes with 9.6 amperes. To effect this a shunt of about 25 ohms but adjustable between 20 and 30 to be placed permanently across the field, reducing the current from 9.6 to $9.6 \times \frac{25}{36}$ or about 6 amperes thus (presumably) reducing the generated EMF from 1370 to $1370 \times \frac{6}{9.6}$ or 860

To light 60, 2 series of 30 lamps in parallel, voltage 635 or 700 at brushes with 6.4 amperes. To effect this the same shunt fixed at about 25 ω would be needed thus reducing the current from 6.4 to $6.4 \times \frac{25}{36}$ or 4.4 in the field and the EMF from 1400 to $1400 \times \frac{4.4}{9.6}$ or about 630, and taking saturation effect into account this would probably be 700.

To light 15 in series of 15 lamps, voltage 320 or 410 at brushes with 3.2 amperes. Without any shunt the current in the field being 3.2 the developed EMF would be over $1400 \times \frac{1}{3} = 470$ say 600. With the same shunt of 25 ω the current in the field would be reduced in the ratio of $\frac{25}{36}$ or the EMF would be about 420.

The requirements are therefore a plug board for making the necessary grouping and a magnet shunt up to 30 ω capable of carrying 5 amperes.



M Magnet
A Armature
S Shunt
B Switch
LL Series of lamps
C Commutator.

For	180	lights	plug in	1 2 + 3	disconnect	S.
"	120	"	"	4 5 + 6	connect	S.
"	60	"	"	7 + 8	"	"
"	15	"	"	9	"	"

Platinoid.

November 7th Wednesday.

100 feet of platinoid strip in 2 lengths gave following results @ 22°C.

No. of length	Measured length in metres	Breadth	Thickness	Area	11 mm Length	Bridge	Resistance	Cond.	Resist. of 1 ft	Spec. Res.			
1	27.462	5·64	0·0406	0·2306	8.25×10^{-7}	Wm. Jr. TB 23°C	0·5214	0·0125	0·5089	4.20×10^{-4}			
2	11.425	5·68	0·0406	0·2306	1.93×10^{-7}		0·2420		0·2295	4.24×10^{-4}			

Municipal Voltmeter test. at 23°C.

Coils 16,650	#1	In Potentiometer slide.	
25,670	#2	from initial terminal to extreme right	75·43
33,770	#3	- - - - 1400 mark	79·20
50,070	#4	- - - - {extreme right} 900	119·03

The calculation is $E = eR \div r + \frac{a\rho}{b}$

where E is the voltage to be measured.
e . . of the cell or cells attached
R . . resistance of the voltmeter at the time
r . . - from the initial terminal to the extreme right or 1500 mark.
ρ - - - between the limits of the slide.
b . . distance between these limits
a . . distance from the point of balance to the 1500 mark.

Here r = 75·4
b = 10·3
ρ = 43·6

∴ the divisor is $75.4 + a \times \frac{43.6}{10.3} = 75.4 + 4.23\,a$.

Taking 2 Daniell cells at 2·1 volts, the 1500 mark would correspond at the full limit of the machine to $\frac{2.1 \times 50{,}070}{75.4} = 1395$ say 1400 volts.

~~The carrying capacity of any cable is~~

Meter Experiments contd —
November 8th.

Took two wide mouthed bottles of about 200 c.c. capacity and placed a fitted pair of freshly amalgamated zinc 25 ct plates in each. Heated one bottle and its contained plates to boiling point over a sand bath, while the other was closed at the normal temperature. Each pair of plates was varnished on the backs and sides. On testing, the resistance of the bottle that had been boiled was about 70ω, that of the unheated bottle about 40ω. The plates of the heated bottle seemed to shew that varnish had been deposited on their faces in a thin layer. Both bottles were externally sealed with paraffine wax.

Took a 25 lt meter bottle whose zincs had been renewed but whose copper electrodes passed through the cork in the usual way. Found the res. (between the electrodes) of the films of $ZnSO_4$ incrustation within, or of moisture without to be exceedingly high (upwards 1Ω). The bottle had been prepared about two days previously and was well shaken up at that time but since then has remained untouched. On shaking up the bottle so as to thoroughly wet the corks on the inside, the resistance fell very much but at no time below 100ω rapidly rising as evaporation removed the internal film.

Resistance of an old 25 light bottle. observed by Mr Watt.

Took a 25 light bottle whose original resistance when made up on the 5th inst. was 1.3ω and measured the fall of resistance with a 4 milliamp current as follows —

No. of Obs.	Time	Time from start	Bridge	Current.	Res: Ω	Leads	Res less leads	Temp bottle or air round		
1	9·10	0.00	100/10	4 milliamps	9.0	0.22	8.78ω			
2	·15	·05			8.0		7.78ω			
3	·20	·10			7.0		6.78ω			
4	·25	·15			6·5		6.28ω	22.5°C		
5	·30	·20			6·3		6·08			
6	·40	~~·30~~			6·15		5·93			
7	·45	·35			5·85		5·63			
8	·50	·40			5·70		5·48			
9	·55	·45			5·55		5·33			
10	10·00	·50			5·40		5·18			
11	·10	1·00			5·20		4·98	21.8°C		
12	·20	1·10			5·00		4·78			
13	·30	1·20			4·85		4·63			
14	·40	1·30			4·65		4·43	22.5°C		
15	·50	1·40			4·58		4·28			
16	11·00	1·50			4·35		4·13			
17	·10	2·00			4·25		4·03			
18	·20	2·10			4·10		3·88			
19	·30	2·20			4·00		3·78			
20	·40	2·30			3·90		3·68			
21	·50	2·40			3·80		3·58			
22	12·00	2·50			3·70		3·48			
23	15·50	6·40			2·60		2·38	23°C.		
24	8·20	23·10			2·50		2·28	22°C.		
	9.11.98									

November 9th Friday.

A 25-light meter bottle was taken and filled with ordinary meter solution. Two unweighed plates well amalgamated, were connected and inserted. The bottle was then put on a sandbath and heated till the solution boiled. The heat was then removed, the lid screwed down tightly and paraffine was poured over the corks and stoppers. The resistance of the bottle shortly afterward when still hot, perhaps at 90°C was observed to be 0·57ω, slowly rising until at 23°C the resistance became steady at 4·32ω. It was then labelled and set aside.

Set up two meter bottles to stand for a week before inserting in meters. Weight (observed by Mr Lawrence) as follows:—

Plates No.	Position	Weight simple	Sum of couple	Observed weight of couple	Discrepancy	Adjusted simple weight	Adjusted weight of couple	Sum as check	Solution
1	vermilion	83·3256	172·1694	172·1690	+0·0006	83·3258	172·1688	172·1688	not heated
2	on back	88·8428				88·8430			
3	and	89·1486	178·4501	178·4502	+0·0001	89·1486	178·4501	178·4501	not heated
4	sides.	89·3015				89·3015			

November 10th Saturday.

Took the resistance of a number of bottles that have been made up at different dates and under different conditions as follows:—

No. of bottle	Date of setting up	Days at rest	Plates	Solution	Page of Record book	Resist. observed 10·11·88	Loss	Resist. of bottle 10·11·88	Current meas.	Bridge	Behavior	Temp.		
VI	31·10·88	10	plain amal	heated 6·88	11	2·6	0·1	2·5	10	100ω	Steady	23°C.		
VII	31·10·88	10	do. do	not heated	11	7·2	-	7·1	-	-	falling	-		
VIII	31·10·88	10	vermilion amal	heated 6·88	11	14·0		13·9	-	-	-	-		
IX	31·10·88	10	do. do	not heated	11	8·5		8·4	-	-	-	-		
X	3·11·88	7	plain amal	heated 6·88	14	3·4		3·3	-	-	-	-		
XI	7·11·88	3	vermil: amal	not heated	–	7·55		7·45	-	-	-	-		
XII	8·11·88	2	vermil: amal	heated 6·88	19	17·3		17·2	-	-	-	-		
XIII	9.11.88	1	plain: amal	heated 6·88	20	4·7		4·6	-	-	-	-		

Test of the chemical purity of the zinc sulphate salt employed for making meter solution. by Mr Lehmann

Iron 0·05 %.

Traces of Arsenic, Copper, Bismuth, and Lead.

Meter Experiments contd:-

November 10th Saturday.

Zinc & oxide res: readings by Mr Wirt.

Bottle D of 25 lt plates set up on the 5th October and left aside since that date was employed.

No of obs	Time	Time from start	Current	Bridge	Res: dead	lead	Res: bottle	Temp	
1	10.22	0.00	2 amp	1000/10	27	0.26	26.74	24°	
2	.23	0.00	8		16		15.74		
3	.24	0.01			7.5		7.24		
4	.25	0.02			6.0		5.74		
5	.26	0.03			5.55		5.29		
6	.27	0.04			5.15		4.89		
7	.28	0.05			4.90		4.64		
8	.29	0.06			4.75		4.49		
9	.30	0.07			4.55		4.29		
10	.31	0.08			4.45		4.19		
11	.32	0.09			4.30		4.04		
12	.33	0.10			4.20		3.94		
13	.34	0.11			4.10		3.84		
14	.35	0.12			4.05		3.79		
15	.40	0.17			3.97		3.71	24.2°	
16	.45	0.22			3.57		3.31		
17	.50	0.27			3.45		3.19		
18	.55	0.32			3.32		3.06	23.8°	
19	11.00	0.37			3.22		2.96		
20	11.10	0.47			3.07		2.81	23.0°	
21	.20	0.57			2.98		2.72		
22	.30	1.07			2.90		2.74		
23	.45	1.22			2.82		2.66		
24	12.00	2.07			2.26		2.09		
25	12.20	5.57			2.22		1.77	23.0°	
26	13.20	26.57			1.73		1.27	22.0°	

November 11th Sunday.

The E.M.F. of two new V Daniell cells for the Municipal voltmeter was (1) 1.093
(2) 1.083 @ 24° C.
sum 2.176 observed by Mr Lawrence 9.11.99

at this value the extreme reading of the instrument is

$$\frac{2.176 \times 50{,}070}{75.4} =$$

= 1445 volts. instead of 1500 as marked.

so that the instrument probably overindicates by 50 volts.

Meter Experiments contd.
November 11th Sunday.

Weighed after drying the plates enumerated on page 3 that have been standing since the 19th October i.e. 23 days: Air has had access to the bath (a large evaporating dish 18.2 cms diam 10.2 high filled to height of 6.9 cms i.e. area 260.2 sq.cms vol: liquid 1820 c.c.) during that time, a cardboard cover simply having rested on it to keep off the dust. The temperature having probably averaged 20° during the interval the density of the solution was observed to have increased from the original 1.05 to 1.07, and the reaction was slightly acid. Weights observed @ follows:-

Plate No	Weighed 19.10.88	% by weight of Hg	Weight before immersion 19.10.88	Weight after drying 11.11.88	Gains	Correction if any.	Gain corrected	Mean Gain.	General Mean.
1	O_1	0 but amalgamated	95.4927	95.5486	0.0559		0.0559	0.0507	
2	O_2	do do	98.2144	98.2598	0.0454		0.0454		
3	O_3	0	87.7266	87.7788	0.0522				
4	O_4	0	88.2990	88.3482	0.0492			0.0507	
5	1_1	1	98.9323	98.9970	0.0647				
6	1_2	1	101.0243	101.0761	0.0518				
7	1_3	1	92.2777	92.3277	0.0500			0.0544	
8	1_4	1	92.4805	92.5309	0.0504				
9	2_1	2	96.6619	96.7211	0.0592				
10	2_2	2	97.9646	97.0166	0.0520	96.9646	0.0520		
11	2_3	2	95.1525	95.2049	0.0524			0.0560	
12	2_4	2	95.2960	95.3543	0.0583				
13	2_5	2	102.5340	102.6920	0.0580				0.0576
14	1_5	1	90.8382	90.8934	0.0552				
15	3_1	3	98.3149	98.3745	0.0596				
16	3_2	3	101.2780	101.3370	0.0590				
17	3_3	3	98.9040	98.9588	0.0588				
18	3_4	3	96.4714	96.5360	0.0646			0.0596	
19	3_5	3	90.8865	90.8955	0.0590				
20	4_1	4	97.6410	97.7032	0.0622				
21	4_2	4	93.8015	93.8630	0.0615				
22	4_3	4	111.6600	111.7244	0.0644			0.0613	
23	4_4	4	99.0824	99.1417	0.0593				
24	5_1	5	101.2153	101.2847	0.0694				
25	5_2	5	99.6741	99.7470	0.0729				
26	5_3	5	104.2170	104.2872	0.0702			0.0708	
27	5_4								

These results show a steady increase of gain in weight with the % of mercury in the alloy. There was no perceptible difference in the appearance of the plates. It so happens that the three pure zinc unamalgamated plates gained on the average just as much as the two pure zinc amalgamated plates.

Weighed 3 other pairs of plates (connected by brass fitting) which have been in solution untouched since the 19th October, when weighed by White

No of couple	Date of immersion	Days left immersed	Condition	Weight before immersion	Weight after drying 11.11.88	Gain		
1	10th Oct.	32	(Amalgamated & varnished only on tops & ends)	172.707	172.8837	0.1767		
2			(Amalgamated & varnished everywhere except on faces)	172.062	172.2226	0.1606		
3			(Varnished over completely)	169.001	169.1704	0.1694		

From the lower table on the opposite page we have assuming a parabolic curve,

a	+	3.1b	+	(3.1)² c	=	4.3·15	=	a + 3.1b + 9.61 c	=	1.135
a	+	28.6b	+	(28.6)² c	=	37.75		a + 28.6b + 818 c	=	0.9996
a	+	25.8b	+	(25.8)² c	=	35.22		a + 25.8b + 665.6c	=	0.927
a	+	23.5b	+	(23.5)² c	=	35.88		a + 23.5b + 552.3c	=	0.9416
a	+	20.7b	+	(20.7)² c	=	35.13		a + 20.7b + 428.5c	=	0.924
a	+	17.9b	+	(17.9)² c	=	38.11		a + 17.9b + 320.4c	=	1.003
a	+	14.8b	+	(14.8)² c	=	40.76		a + 14.8b + 219.0c	=	1.073
a	+	11.7b	+	(11.7)² c	=	46.30		a + 11.7b + 136.9c	=	1.218
a	+	7.9b	+	(7.9)² c	=	53.56		a + 7.9b + 62.4c	=	1.521
a	+	4.1b	+	(4.1)² c	=	94.41		a + 4.1b + 16.8c	=	2.485
a	+	2.4b	+	(2.4)² c	=	170.0		a + 2.4b + 5.76c	=	4.474
a	+	15.8b	+	(15.8)² c	=	39.0		a + 15.8b + 249.6c	=	1.000

The normal equations are (regarding the first 10 as of the 10 series equal)

12a	+	204.2b	+	4436.3c	=	17.718		12a + 95.3b + 1439.4c	=	12.714
3.1a	+	96.1b	+	29.791c	=	35.18		96.1a + 29.791c		
28.6a	+	818b	+	23.394c	=	29.42				
25.8a	+	665.6b	+	17.173c	=	23.42				
23.5a	+	552.3b	+	12.974c	=	22.19				
20.7a	+	428.5b	+	8.870c	=	19.12		428.5a + 8870b + 183600c	=	396
17.9a	+	320.4b	+	5.735c	=	17.95		320.4a + 5735b + 128000c	=	321
14.8a	+	219.0b	+	3.112c	=	15.88		219.0a + 3.112b + 47.960c	=	235
11.7a	+	136.9b	+	1.602c	=	14.25		136.9a + 1.602b + 18.770c	=	167
7.9a	+	62.4b	+	4.93c	=	12.18		62.4a + 4.93b + 3.840c	=	96
4.1a	+	16.8b	+	.96c	=	10.19		16.8a + .96b + 2.532c	=	42
2.4a	+	5.76b	+	.16c	=	11.37		5.76a + .16b + .332c	=	26
15.8a	+	249.6b	+	3.94c	=	15.80		249.6a + 3.94b + 62.500c	=	250
(3)		95.3a	+	1439.4b	+	23.83c	=	116.74		1439.4a + 23.83b + 440.678c = 1533

(4)	8a	+	95.3b	+	1439.4c	=	13.72			
(5)	95.3a	+	1439.4b	+	23.83c	=	116.74			
(6)	1439.4a	+	23.83b	+	440.678c	=	1533			

From (4)

$$a = -\frac{95.3b}{8} - \frac{1439.4c}{8} + \frac{13.72}{8}$$

$$= -11.91b - 179.9c + 1.72$$

(5) $-95.3 \times 11.91b - 95.3 \times 179.9c + 95.3 \times 1.72 = 116.74 - 1439.4b - 23.83c$

$$-1135b - 17150c + = +116.7$$
$$+1439.4b + 23.83c = -163.9$$
$$7 + 3026b + 6689c = -47.2$$

From (7)

$$b = \frac{-6689c}{3026} - \frac{47.2}{3026}$$

$$= -22.0c - 0.155$$

(6) $-1439 \times 11.91b - 1439 \times 179.9c + 1439 \times 1.72 + 23.83b + 440.678c = 1533$

$$-17150b - 258,000c + 2475 \} = 0$$
$$+23.83b + 440.678c - 1533 \}$$
$$6709b + 181,778c + 942 = 0$$

$$-6709 \times 22.0c - 6.709 \times 0.155 + 181,778c = -942$$

$$-147,500c + 181,778c = -942 + 1040$$

$$\cancel{33,278c} = 1098$$

$$c = \cancel{+0.0033}\ 0.0302 \quad +0.002865$$

$$b = -22.0 \times 0.00287 - 0.155$$

$$= -0.063 - 0.155 = -0.219$$

(7) $95a = +1439 \times 0.219 - 23.83 \times 0.00287 + 116.74$

$$= 315.1 - 6.84 + 116.74$$

$$= 363.4$$

$$a = 3.814$$

(4) $8 \times 3.814 - 95.3 \times 0.219 + 1439.4 \times 0.002868 =$

Proof

$$30.5 - 20.87 + 4.13 = 13.76$$

$$1439 \times 3.814 + 23.83 \times -0.219 + 440.678 \times 0.002868 =$$

$$5489 + -5221 + 1264 = 1532$$

Sulphate of Zinc solution
Specific Res. and Temp. Coeff.

The following table gives a resume of the values obtained for the spec. res. near the 3 temps 5°, 20° & 50° for different strengths of solution. Then these assuming the empirical relation $\rho = a + bt + ct^2$ the values of a b and c are given.

No. of Obs.	Date	Density of Solution	Specific Res. observed @ 5°	20°	50°	Calculated values of a	b	c	Coefficients a	b	c
1	10th Oct 83	1·397 @ 20°	34·91	4·9	21·04	21·6	11·61	49·1	+ 4·315	− 1·323	+ 0·0138
2	11th . .	1·360 @ 20°	32·21	5·4	21·32	19·0	11·29	46·4	+ 3·775	− 1·089	+ 0·0118
3	11th . .	1·318 @ 24°	31·23	4·6	21·30	18·4	11·64	45·3	+ 3·522	− 0·963	+ 0·00795
4	12th . .	1·283 @ 16°	29·76	6·4	21·57	16·9	10·83	57·6	+ 3·588	− 1·023	+ 0·0104
5	12th . .	1·243 @ 23°	25·94	7·3	21·17	18·5	11·54	48·8	+ 3·513	− 0·920	+ 0·0089
6	14th . .	1·203 @ 21°	33·01	5·2	21·62	19·8	12·98	48·8	+ 3·811	− 1·035	+ 0·0102
7	15th . .	1·166 @ 22°	35·82	4·9	24·34	19·3	14·18	51·2	+ 4·0·76	− 1·052	+ 0·0104
8	16th . .	1·128 @ 19°	39·51	6·0	29·64	16·6	16·15	51·5	+ 4·6·3	− 1·207	+ 0·0121
9	17th . .	1·084 @ 21°	50·55	6·1	32·54	23·9	20·62	53·4	+ 5·8·56	− 1·383	+ 0·0126
10	17th . .	1·043 @ 20°	65·88	15·1	57·39	44·4	34·26	51·9	+ 9·4·41	− 1·89	+ 0·—
11	18th . .	1·025 @ 21°	14·5	5·8	96·6	20·2	58·14	52·2	+ 170	− 4·573	+ 0·0467
12	19th . .	1·17 @ 20°	34·24	5·0	19·51	26·4	12·88	52·2	+ 38·92	− 0·978	+ 0·00917
									+ 3·6·0	− 0·931	+ 0·0088

No. of Obs.	Calculated values of a	b	c	Coefficients a	b	c
1	1·00	1·00	1·00	1·00	1·00	1·00
2	1·11	1·32	1·57	1·57	1·21	1·57
3	1·12	1·11	1·21	1·21	1·11	1·21
4	0·97	1·17	1·32	1·32	1·17	1·32
5	0·91	0·97	2·36	2·36	0·97	2·36
6	0·92	1·04	1·13	1·13	1·04	1·13
7	0·99	1·05	1·18	1·18	1·05	1·18
8	1·05	1·07	1·11	1·11	1·07	1·11
9	1·05	1·13	1·13	1·13	1·13	1·13
10	1·12	1·23	1·32	1·32	1·23	1·32
11	1·50	1·40	1·37	1·37	1·40	1·37
12	1·54	1·65	1·63	1·63	1·65	1·63

The tabular % for sp. gr. 1·397 is stated at anhydr. $ZnSO_4$ 31 reckoned 31

1·360	28·6	0·7	27·9
1·318	25·8	1·0	24·8
1·283	23·5	1·8	21·7
1·243	20·7	3·1	18·6
1·203	17·9	2·4	15·5
1·166	14·8	2·6	12·2
1·128	11·7	2·4	9·3
1·084	7·9	1·7	6·2
1·043	4·1	1·0	3·1
1·025	2·4	0·8	1·6

Accepting the tabular figures we have.

No. of Obs.	Density of Sol.	Tabular % $ZnSO_4 + 7H_2O$	Tabular anh. $ZnSO_4$	% $ZnSO_4 + 7H_2O$ by calculation	% $ZnSO_4$ anh. by reckoning	discrepancy	coeff. a	ratio a standard
1	1·397 @ 20°	55	31	58·2	31	0·8	43·15	1·114
2	1·360 @ 20°	51·0	28·6	52·4	27·9	− 0·7	37·75	0·99
3	1·319 @ 24°	46	25·8	46·6	24·8	− 1·0	35·22	0·93
4	1·283 @ 16°	42	23·5	40·7	21·7	− 1·8	35·88	0·94
5	1·243 @ 23°	37	20·7	34·9	18·6	− 2·1	35·13	0·92
6	1·203 @ 21°	32	17·9	29·1	15·5	− 2·4	38·11	1·00
7	1·166 @ 22°	27·5	14·8	25·3	12·4	− 2·4	40·76	1·07
8	1·128 @ 19°	21	11·7	17·5	9·3	− 2·4	46·30	1·22
9	1·084 @ 21°	15	7·9	11·6	6·2	− 1·7	53·56	1·54
10	1·043 @ 20°	7·5	4·1	5·8	3·1	− 1·0	94·41	2·48
11	1·025 @ 21·8°	5	2·4	3·6	1·6	− 0·8	170·0	4·47
12	1·17 @ 20·0°	28·3	15·8	30·5			38·0	1·00

Rule for calculating the sp. res. of pure neutral $ZnSO_4$ of density less than 1·3 @ 20°C.

Find the density @ 20°C ... From this and Watt's tables find the % of anhydrous salt in the solution, let it be n.

Calculate $3{\cdot}8114 - 0{\cdot}219n + 0{\cdot}00287n^2$. Let it be p

Calling the temp °C t

$$\rho = p(38{\cdot}0 - 0{\cdot}931t + 0{\cdot}0031t^2)$$

Res. of Galv. 7935·5 (at 27·2)
@ 22·6 = 46·6 × 0·38 = 0·1748 × 7935·5 = 13·9

13·9
7935·6
2000.

2) 9938·6
6991 × 179 = 6991 divs corresponding to $\frac{1.429}{300,000} = \frac{1.429}{3 \times 10^5} = 0.476 \times 10^{-5}$

$= 4.76 \times 10^{-6}$ ampere

1 div $= \frac{4.76}{6.91} \times 10^{-6} = 0.69 \times 10^{-9}$ ampere $= 6.89 \times 10^{-10}$ c.c.

The current obtained in any experimental case through the galvanometer is $C/32,000 \times 10^3$ where $C = C \times 24.7 \times 10^{-3}$ =

$\frac{2.47\, C \times 10^{-3}}{3.28 \times 10^{-10}}$ ∴ $C = \frac{3.28}{2.47} C \times 10^3 = \frac{3.28 \times 6.89 \times 10^{-9} d}{2.47}$ where d. = defln

$= 0.915\, d.$

Octopolar Dynamo Test
November 12th Monday.

14·03 Started running Octopolar, exciting from 130 volt machine.
10 wires of overhead line in circuit, volts 100 ammeter 275 Deflection on Galvanometer 38 divs:
Constant of Galvanometer 300,000 6.1 K in cct with Galv. 2000 – Shunt
Defln 179 Temp. 22·6°C.
Increased wires to 18 and deflection to 63 divs.
This current heated the cables in the room to smoking temperature so cut it off about 14·35. Temp. 154° F.

15·03 Commenced running again. Zero reset.

·05	107	200	6	24	=	119 amp.	calculated.	
·07	103	320	10	37·5	=	343		
·09	98·5	410	13	46	=	421		
·11	105		16	63·8	=	584		
·13	101·5		20	72·5	=	663		
·15	97		24	83	=	759		750 revs
·18	92·5		28	89·8	=	822		76,000 Watts.
·19	90			87	=	796		
·21	88			83	=	760		
·25	84		30	80·2	=	734		
·35				79	=	723		
·42				73·5	=	672		
·53	75·5			73·5	=	672		

Shut down and took temp. of 204·5°F.
Altered engine governor to obtain a greater speed than the last 236.

16·09 Started engine speed 265 at driving wheel, and 850 at Dynamo.

·22	135 volts	430 amps. indicated	10 wires in cct.	Defl. 45·5	=	416	
·25	115		19	70	=	640	
·27	107		23	79·2	=	725	77,500 Watts

Temp of periphery of armature lost on this occasion.
No symptom of overheating wires on the poles or the connecting wires through the woodwork, the greatest current on each overhead circuit being 42 amps.
At the pressure of 100 volt, each overhead wire takes about 30 amperes.

Meter Experiments contd.

October 12th Monday.

Took down bottle containing 2 separate 25 light plates that have stood since October 22nd at the average temp: of about 20°C. Solution 1.054.

No of plate	Date of immersion	Date of emersion	Condition of plate (varnish measure)	measure.	Weight 22.10.88	Weight 12.11.88	Gain	Presumed Weight of Zinc (Mean of 2 plates)
1	22.10.88	12.11.88	Zinc not wet protected, not varnished on top or rod.	Amalgamated	86.5452	86.6112	0.0660	0.0616
2	-	-	Varnished - (not protected)	Not amalgamated	92.1340	92.2616	0.1276	

Measurement of the amount of Zinc sulphate in the solutions previously tested for specific resistance. by Mr Emmerson

3 specimens of solutions were taken on the 22nd October each just 50 c.c. by means of the sp. g. bottle, one of the original or 100% sol: one of the 30% sol. and one of the 5% sol. These specimens in weighed evaporating dishes were set aside to evaporate under muslin dust cover. The crystal residue and dishes were finally weighed on the 12th November.

No of No.	% Sol.	Weight of 50 c.c.	sp. g.	sp. g. by record. (by M. & Inness)	Weight of dish (11.11.88)	Weight of dish	Weight of crystal + $ZnSO_4$ + $7H_2O$	% by weight of crystal	% by table corresponding to sp. g. obtd.
1	100	69.7431	1.3949	1.396	82.2727	41.6250	40.6477	58.2	55
2	30	58.9513	1.1790	1.179	72.3620	54.3495	18.0125	30.5	28.3
3	5	51.0993	1.0220	1.025	83.9700	82.4030	1.5670	3.6	3.8

These numbers agree therefore very fairly with those given in the tables corresponding to the sp. g. observed. @ 20°C.

The Resistance of the Astatic Thog Galvanometer on the 5th table was observed at 2 temperatures on two successive days during the resuspension of the mirror as follows:—

No of Obn	Bridge	Res. obtd.	Leads	Res obtd. of Galvn.	coil L.T.B.	T. g.	T. B.	(1) calculated for (1)	calculated to 20°C.
1	1000/1000	7950	0.5	7949.5	7960.4	24.8°C	23.6°C		7815
2	"	8035		8034.5	8046.9	26.6°C. (by 2 thermms)	24.2°	8015.	7845
								Mean	7830 ± 20Ω

Res. of galv. 8034 = 26.5 Ω.

at 8000 = 20000 for multiplying power of 5.0

so that constant of 1.43 will and 300000 = gives galv. deflection

i.e. 1 div. corresponds to a current of $1.43 \times 10^{-5} / 9.00 \times 10^{7} \times 3.00 \times 10^{10}$

$= 1.43 \times 27 \times 10^{-15} = 5.3 \times 10^{-15}$

Octopolar Dynamo Tests
November 13th Tuesday

		Volts at Terminals	Symbol Wire in cct.	Amperes in Field	Ohmmeter Reading	Shunt Deflection			26 Amps. calculated
8.07	Commenced running Octopolar	133	3	21.5	160	28	53		
8.15	" " "	133	6	20.5	275	55	50		
.20		133	9	20.0	400	77	52		
.23		131	13	19.5	—	105			546
.25		127	16	19	—	125			620
.30		122	19	18.5		146			757
.31		119	20	18.5		152			790
.32		116.5	20	18.0		147			764
.33		113	21	17.0		150			780
.35		125	21	22.5		157			816
.37		119	21			147			764
.50		115	22			142			749
9.35	Speed of dynamo 817 revs.	113	24	19.5		148			770
.20		118	24	23		155			806
10.02		123	24	22.5		159			827
11.00		122	24	22.5		—			
11.02	Band nearest to pulley on armature carried away at a soldered joint. Stopped machine, and took temperature. Highest reached 298°F								

The load during the last two hours had been on the average $820 \times 122 = 100{,}000$ Watts.

The P.D. on the magnet coils (in 2 parallel set of 8) must have been at least 260 volts, and the current in each series being about 11.5 ampere = 2990 Watt ÷ 8 = 375 Watts per coil expended in heat. This continued steadily for 2½ hours steadily raised the temp. to about 170° F. As this was hardly fair to the armature it becomes necessary to consider the best method of rewinding the magnets in order to generate the same amount of magnetism with less heat. The machine to be selfexciting and to be allowed as much as 30 lbs of wire to each magnet coil. The present winding is 20 lbs of #15 BWG wire on each of the 16 coils.

The possible combinations to be considered are :-

(1) All 16 coils in series
(2) Two series of 8 each
(3) Four " " 4 "
(4) Eight " " 2 "
(5) Sixteen " " 1 "

It is required to find the winding for best effect.

The present No. of layers on each coil is 7.6, the number of turns to a layer 81

Total no. of turns 616.

Since 12 ampere has to be provided for, the total number of ampere turns on each coil must be 616 × 12 = 7300 nearly

$$r = \frac{v}{N \pi d} = \frac{130}{750 \times n \times 2{\cdot}1} = \frac{1{\cdot}30 \times 10^{1}}{n \times 7{\cdot}3 \times 2{\cdot}1 \times 10^{3}} = \frac{13{\cdot}0 \times 10^{-2}}{n \times 15{\cdot}33} = \frac{8{\cdot}4 \times 10^{-4}}{n}$$

where $n = 1$ $\quad r = 8{\cdot}48 \times 10^{-4}$

" $n = 2$ $\quad r = 4{\cdot}24 \times 10^{-4}$

" $n = 4$ $\quad r = 2{\cdot}12 \times 10^{-4}$

" $n = 8$ $\quad r = 1{\cdot}06 \times 10^{-4}$

" $n = 16$ $\quad r = 53 \times 10^{-6}$

Octopolar Dynamo.

Calculations for winding field magnets.

Problem. Having given the number of ampere-turns necessary to produce a certain magnetisation, and the weight of wire available on each coil, to find the size of wire needed and the heat energy expended in it.

Let c be the current in each magnet coil

" t " " number of turns on each coil.

" v " " mean normal voltage required from the machine

" R " " resistance when hot of each coil

" n " " number of coils in series

" d " " mean diameter of one turn in feet.

" r " " resistance per foot of the wire required.

" N " " number of ampere-turns

Then

$$N = ct$$

$$c = \frac{v}{nR}$$

$$R = \pi d t r$$

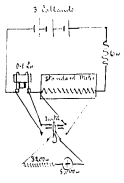
$$\therefore N = \frac{vt}{n \pi d t r} = \frac{v}{n \pi d r} \quad \therefore r = v / N n \pi d$$

In this particular case $N = 7300$ $\pi d = 2{\cdot}1$

From these data we obtain the following table.

Arrangement of coils	Res per foot formula	Resist. in Ω	Bare wire diameter in inches	Current per coil	Total current	Highest volts required	Total Watts expended	Watts expended in each coil	Total Res of each branch	Res of all finally
16 in series	$5{\cdot}3 \times 10^{-4}$	0·165" #8	0·138	59	59	130	7650	480	2·25	2·21
2 series of 8	$1{\cdot}06 \times 10^{-3}$	0·095" #12	0·26	12·7	24·2		3150	19·4	19·8	5·4
4 series of 4	$2{\cdot}12 \times 10^{-3}$	0·072 #15	3·51	9·3	37·2		4840	303	14·0	3·51
8 series of 2	$4{\cdot}24 \times 10^{-3}$	0·049 #18	17·8	3·7	29·0		3770	236	35·6	4·45
16 series of 1	$8{\cdot}48 \times 10^{-3}$	0·035 #20	68·1	1·9	30·5		3970	250	68·1	4·25

It will therefore be best to add 10 lbs of wire to each magnet coil, of same wire, making 16 lbs in all of #15 increasing the length from 7·6 to perhaps 11·6 all told. making the refill 1·85".



Calculation of Probable Error

No. of obs.	Obs.	Mean	Residual v	v^2	Σv^2	$\sqrt{\frac{\Sigma v^2}{n(n-1)}}$	0·6745 $\sqrt{\frac{\Sigma v^2}{n(n-1)}}$	Adjusted value of Meter #1
1	0·99370	0·99352	+0·00082	6.72×10^{-6}				
2	0·99488		+0·00086	7.38×10^{-6}			0·2754 × 0·00106 = 0·000292	0·99445 ± 0·000029 @ 21°C
3	0·99457		+0·00065	4.25×10^{-6}	112.05×10^{-6} 1.1205×10^{-4}	1.06×10^{-3} 0·00106		
1	0·99652	0·99712	+0·00060	36.0×10^{-6}				
2	0·99900		−0·00188	353·4				
3	0·99678		+0·00034	11·6				
4	0·99752		−0·00040	16·0				
5	0·99801		−0·00099	79·2			0·0795 × 0·00267 = 0·00021	0·09980 ± 0·000021 @ 21°C
6	0·99702		+0·00010	1·0				
7	0·99652		+0·00060	36·0				
8	0·99702		+0·00010	1·0				
9	0·99579		+0·00133	176·9	711.1×10^{-6} 7.111×10^{-6}	2.67×10^{-3}		

Meter Experiment contd :-

November 15th Thursday.

Measured the resistance of the shunts and spools of the two new standard Meters made at the laboratory, by comparison with the 0·1 standard lent by Mr Bergmann.

Found up connections shewn so that the switch could change the PD easily without much disturbance of the spot under a lens.

Meter Number 1

No. of obs.	Deflection on Meter	Deflection on Standard Meter	Temp. of Standard 0·1	True Res. of Std. at temp.	Differential Difference	Ratio	True value of Meter	Temp. of Meter	Probable Temp. at which Meter becomes correct
1	405·8	403·0			2·8	0·99310	0·9937		
2	405·8	403·4	20·2°C	0·10006	2·4	0·99408	0·9947	21·5°C.	48°C.
3	405·6	403·4			2·2	0·99457	0·9952		
Mean	405·73	403·27			2·46	0·99392	0·99452		

Meter Number 2

No. of obs.	Deflection on Meter	Deflection on Standard 0·1	Difference	Ratio	Temp. Std. 0·1	True Res. of Std. at temp.	True value of Meter	Temp. of Meter	Probable Temp. at which Meter becomes correct
1a	401·5	402·9	1·4	0·99652					
1	401·4	401·8	0·4	0·99900					
2	402·0	403·3	1·3	0·99678					
3	402·5	403·5	1·0	0·99752					
4	402·2	403·0	0·8	0·99801	22·0°C.	0·10009			
5	402·0	403·2	1·2	0·99702					
6	402·0	403·4	1·4	0·99652					
7	402·0	403·2	1·2	0·99702					
8	401·8	403·5	1·7	0·99579					
Mean	401·93	403·09	1·16	0·99712			0·99802	21°C.	31°C.

Experimental Standard Meter

No. of obs.	Deflection on meter	Deflection on Std. 0·1	Difference	Ratio	Temp. Std. 0·1	True Res. of Std. at temp.	True value of Meter	Temp. of Meter	Probable Temp. at which Meter comes correct
1	397·1	405·0	7·9	0·98049					
2	397·5	404·5	7·0	0·98269	22·0°	0·10009			
3	397·5	404·6	7·1	0·98245					
Mean	397·37	404·70	7·33	0·98188			0·98276	20°C	59°C.

Meter Experiments contd.

November 15th Thursday

Checked the above measurements by bridge.
Used 4 stout wires of equal length as leads two for the meter and two for the standard tenth.
The resistance of all these four together was observed to be 0·01053 or 0·00527ω per pair.

Meter No. 1.

No. of Obs.	Bridge	Calculated Balance on Std.	Calculated Balance on Meter	Leads.	Corrected for leads O-Std.	Corrected for leads Meter.	Ratio	Value of O-Std at temp	Calculated value of Meter
1	1000/10 24·1°C	0·10505		0·00527	0·09978	0·09926	0·9948		
2			0·10453					0·10006	0·9957ω @ 22°C.
3		0·10480			0·09953	0·09910	0·9957		
4			0·10437						
Mean		0·10493	0·10445	0·00527	0·09967	0·09918	0·9951	0·9957	
1	1000/10 24·1°C	0·10505		0·00527	0·09978	0·09935	0·9957	0·10006	0·9963ω @ 22°C.
2			0·10462						

Resistance of spool and left hand wire to spool.

Meter	Bridge	Balance	Balance Corrected	Mean.	Leads.	Cor. for Leads	Cor. for TB to 15°C.	Temp. spools	
1	1000/10 24·1°C	97·91	97·88	97·90	0·02	97·88	98·03	22°C.	
2		97·91	97·89	97·90	0·02	97·88	98·03		

Calculation of Probable Error.

Meter	Obs. ratio cor. for leads	Mean.	Residual v	v^2	Σv^2	$\sqrt{\Sigma v^2}$	$0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$	ε	Adjusted value
1	0·9948	0·99525	0·00485	20.25×10^{-6}	40.5×10^{-6}	6.36×10^{-6}	0.4769×0.00062	±0·0003	0·9957 ± 0·00003
2	0·9957		0·00445	20.25×10^{-6}					

Measured the resistance of 25th bottles Nos. VI and VII which have been left untouched since the 10th inst.

Bottle No.	Plate Nos.	Bridge	Current thro bottle	Res. in ect.	Res. dead	Leads.	Res. of bottle	Temp. of bottle.	Days standing
VI	1+2	1000/10	1 milliampère	7000ω	2·22	0·26	1·96	20°C.	15
VII	3+4				32·00	~~24·74~~	31·74		

Plates Nos. 1 + 2 unvarnished, but amalgamated, still retain their bright lustre though covered by bubbles of gas.

Meter Experiments contd:

November 16th Friday.

Measured the resistances of the 25 lt meter bottles observed yesterday and on the 10th inst.

No. of Bottle	Date of bottling by	Days at rest	Plates	Solution	Pages of Rough Book	Results observed 16.11.88	Leads	Wt. of bottle	Bridge, Remarks &c.	Temp. Bottle
VI	31.10.88	16	plain amal.	varied b/50°	11, 20, 29	2.4	0.26	1.85	temp/o	22.1°C
VII	- - -	16	" "	not heated	11	39.7		38.42	7000 = in circ	
VIII	- - -	16	corrodes amal.	varied b/70°		16.2		15.92		
IX	- - -	16	do. do.	not heated		30.2		29.92	1 micromp.	
X	3.11.88	13	plain amal.	varied b/50°		23.3		23.04	Rhea. bottle	
XI	7.11.88	9	corrs. amal.	not heated		53.0		52.74	for few moments	
XII	8.11.88	8	corrs. amal.	varied b/60°		100.		99.74	only	
XIII	9.11.88	7	plain amal.	varied b/60°		6.3.		6.04	No falls in res. observed with any bottle	

To ascertain whether a clean zinc surface suffered any corrosion at the boundary surface between pure zinc sulphate solution and air, took a Leclanché zinc rod and after amalgamating it passed it through a cork into a test-tube half filled with ordinary meter solution and set it aside labelled no. XIV

November 17th Saturday

To ascertain whether a clean copper surface suffered any chemical change beneath when immersed in meter solution, took a test-tube of clean meter solution and immersed in it a strip of copper foil cleaned by nitric acid. Labelled XV

To ascertain once more whether any advantage as regards weight of oxidisation resulted with zinc alloyed with a small percentage of mercury, took 6 new plates of the dimensions and properties recorded on page 3, after weighing left them in meter solution, contained in an evaporating dish.

No. of plate	% of Hg alloyed	Condition of surface	Weight in air by Sartorius 11.11.88	Weight in water	Discrepancy	Adjusted Sartorius Weight	Adjusted Bridge Weight	Sum as check	Labelled	
O_5	0	plain	94.6747	189.6070	+ 0.0005	94.6769	189.6068	189.6069		
O_7	0	"	94.9298			94.9300				
O_1	0	amalgamated	87.2607	176.6378	+ 0.0006	87.2609	176.6376	176.6376	XVI	
O_9	0	do	89.3765			89.3767				
I_1	1	plain	95.1988	184.1062	+ 0.0005	95.1990	184.1060	181.1061		
I_7	1	do	88.9069			88.9071				

$\log 1.00388 = 0.0016828 \times 25 = 0.042070 = 1.1017$

$0.1017\ R = 0.87$

$R = 8.55$

$\log 1.005 = 0.0021661 \times 25 = 0.054153 = 1.1328$

$0.1328\ R = 0.87$

$R = 0.55$

Calculation of the best method of compensating the temp. error in the bottle resistance. (31)

Let C = the service current

" c = " current passing through the bottle

" b = " resistance of the bottle

" r = " " " " spool.

" s = " " " " shunt.

Then $c = \dfrac{Cs}{b+r+s}$

and $\dfrac{dc}{db} = \dfrac{-Cs}{(b+r+s)^2}$

From the curves representing the sp. res. of 2w50 solution, it would seem that the spec. res. of solution having a density of 1.0514 would be 32w @ 50° C.

38w @ 40° C.
45w @ 30° C.
50w @ 20° C.
70w @ 5° C.

Assuming the res. of a 25lt. bottle to be 1.75w @ 20° C.
its res. would be $\dfrac{1.75 \times 70}{50}$ = 2.45w @ 5° C.

and $\dfrac{1.75 \times 45}{50}$ = 1.58w @ 30° C

The res. of the bottle changes from 1.58 to 2.45 or 0.87w between 30° and 5° C. and the problem is to find the resistance of copper whose coeff. of temp. is 1.00388 or of iron whose coeff. is 1.005. will bring about an equal change between these temperatures. We have therefore $R(1.00388)^{25} - R = 0.87$ and $R(1.005)^{25} - R = 0.87$

whence $R = 8.55$ @ 5° C and $R = 6.55$ @ 20° C

$= 9.04$ @ 20° C

9.38 @ 30° C by Lobb's c.s.

If through oxidation, the resistance of a bottle increases by y show the percentage of reduction in current passing through the bottle will be $\dfrac{100y}{b+r+s+y}$

When $b+r+s = 10$ the effect of 1w is to reduce the current 9.1%

" 2w " " " " 16.7%

" 3w " " " " 23. %

" 4w " " " " 28 %

" 5w " " " " 33.3%

If the resistance of the bottle were doubled by diminishing the area of the plate, the spool resistance would also be doubled and with $b+r+s = 20$

the effect of 1w extra in the bottle would reduce the current 4.5%

" " " 2w 8.4 "

3w 11.5 "

4w 14.0 "

5w 16.7 "

It seems probable that the oxide error would be increased in like proportion, since if ρ be the film res. per sq. cm. then the res. of the present plate film is $\dfrac{\rho}{A}$ A being the effective plate area. When A is halved this becomes $\dfrac{2\rho}{A}$

Meter Experiments contd —

November 19th Sunday.

Before taking down the bottles that have been in operation on the meter heat since the 5th inst. took the resistance of each after

No of bottle	Name of meter	Temp of meter	Bridge	Res. in ohms	Current	Res.	Leads.	Res. bottle	Calculated % Difference	
1-2	Standard	15.6°	1000/10 17.19	7000	1 microamp	3.70	0.26	3.44	1.7%	
3-4	#2 bottle	20.0°				3.20		2.94	12 %	
5-6	- -	-				2.70		2.44	76%	
7-9	#1 cold	7°								
10-11	- -					4.50		4.24	17%	
						3.75		3.49	12.4%	

Took down bottles dried and weighed plates as follows —

No. of bottle	Weight empty 17.11.88	Joint weight	Sum of weights	Discrepancy	Adjusted single value	Adjusted joint value	Adjusted single value 19.11.88	Loss	Gain	Calculated Standard loss	% Error
1	86.4905	174.4434	174.4434	+ 0.0010	86.4908	174.4452	87.1900	0.7072	0.7072	0.7196	
2	87.9539				87.9542		87.2381	~~0.71~~	0.7161		
3	88.3127	170.0195	170.0188	+ 0.0007	88.3129	170.0193	87.6248		0.6881		
4	81.7061				81.7063		82.3766	0.6703			4.38
5	89.8530	176.4250	176.4250	+ 0.0006	89.8530	176.4254	89.1537		0.6995		
6	86.5720				86.5722		87.2421	0.6899			4.14
8	85.9396	173.7141	173.7134	+ 0.0007	85.9398	173.7139	86.5614	0.6216			
9	87.7739				87.7740		87.1439		0.6301		13.62
10	86.8855	173.9925	173.9902	- 0.0007	86.8853	173.9937	86.2296		0.6557		
11	87.1057				87.1035		87.7508	0.6423			10.75

No of exp.	No of Meter	Mean temp	Loss.	Mean Cell loss	Diff Temp	Ratio Cell loss / Meter loss	% Error per °C.	Gain by oxidation	Standard values 20.10.88 Ratio Cell loss / Meter loss	% Error per °C	Joint Meter 20.10.88 Gain by oxidation
1-2	Std.	18°	0.7072	0.7196				0.0091			0.0296
3-4	#2	24.5°	0.6703	0.6802	16.5°	1.0581	0.42	0.0178	1.073	0.19%	0.04187
5-6			0.6899					0.0095			0.044422
7-9	#1	8°	0.6216	0.6320		1.139		0.0085	1.109		0.04112
10-11			0.6423					0.0138			0.05742
							Mean	0.0116			0.04443

% of oxidation reduced. 74%

All the plates in the heat just completed were varnished on back and edge, thus reducing the oxidation weight excess to one fourth its former amount, but in the same number of days exposure, but not altering the meter error due to extra resistance, except in so far as the resistance of the bottles may have been increased by reduced surface.

Meter Experiments contd:

November 19th Monday

Set up a new meter comparison test between the three standard meters and the two commercial meters. Also bottles in the three standard meters contained solution that had been raised to 90°C before the immersion of the zincs. One bottle in each of the commercial meters was similarly heated, the other bottle being set up at Normal temperature in the usual way.

No. of Bottle	Condition	Weight singly	Sum	Observed weight of pair	Difference	Adjusted single weights	Adjusted pair weights	Sum as check	Bottle Entitled No.	Meter
1	Immersed	85·6352	175·4699	175·4702	+0·0003	85·6353	175·4701	175·4701	XVII	Standard #1
2	except	89·8347				89·8348				
3	at base	88·9011	177·8263	177·8270	+0·0007	88·9013	177·8268	177·8267	XVIII	Standard #2
4	of rods	88·9252				88·9254				
5	and	81·1423	169·1865	169·1870	+0·0005	81·1425	169·1868	169·1869	XIX	Exp. Standard
6	on rods	88·0442				88·0444				
7	thereafter,	81·8794	172·0906	172·0912	+0·0006	81·8796	172·0910	172·0910	XX	Meter #2 A
8	Amalgamated	90·2112				90·2114				
9	3 times	89·0542	178·4463	178·4460	−0·0003	89·0541	178·4461	178·4461	XXI	Meter #2 A
10		89·3928				89·3920				
11		91·6106	180·2523	180·2525	+0·0002	91·6107	180·2524	180·2525	XXII	Meter #2 B
12		88·6417				88·6418				
13		87·6481	169·2161	169·2165	+0·0004	87·6482	169·2164	169·2163	XXIII	Meter #1 B
14		81·5680				81·5681				

Bottles XVII to XXI inclusive were heated XXII and XXIII left unheated.
Took the resistance of these and other bottles as follows:—

Bottle No.	Varnish	Solution	Date	Page of work	Bridge	Resistance	Current	Res. read corrected for load	Temp. of air in room	Remarks
XVI	on rods only	heated	31.10.88	11, 22, 29, 30	1000/10	7000	1 microamp.	1·82	26·4°C	
XVII	- - -	not heated	- - -	- - - -	-			30·0		
XIV	back & rims	not heated	9.11.88	20				8·19		
XV	- -	not heated	- - -	-				30·0		
XVII	on rods only	heated	19.11.88					1·52		Still warm
XVIII	- - -	-	-					1·44		" "
XIX	- - -	-	-					1·51		- -
XX	- - -	-	-					1·84		- -
XXI	- - -	-	-					1·46		- -
XXII	- - -	not heated	-					1·16		
XXIII	- - -	not heated	-					1·49		

Resistance of Meter spools before closing circuit

No. of Spool	Meter	Spool	Res. read	Leads	Cold for load	Meter	Spool	Res. read	Leads	Cold for load
1	Edison #1a	Left hand	8·50	0·27	8·23	Edison #2 warm	A	8·53	0·27	8·26
2		#2	8·45		8·18		B	8·52		8·25
3		#3	8·44		8·17	Edison #1 cool	A	8·30		8·03
4		Right hand	7·59		7·32		B	8·37		8·10
5	Exp. Standard		98·45		98·18					

Current of 3·8 amperes put on at 16 o'clock.

Experiments on the antiseptic power of Gasolene Rhigolene & Benzic Potash.
by Dr. Dockins

To ascertain whether the admixture of gasolene to an organic solution will prevent or retard bacterial development. 5 test tubes were taken on the 27th October and filled with fresh undecomposed urine mixed with gasolene in the following proportion.

#1	5% Gasolene
#2	10% "
#3	20% "
#4	50% "
#5	Plain urine

These were set aside and occasionally shaken.

#5 showed plenty of live bacteria after 24 hours on the 1st Nov.
#1 - very few motionless - - - - - - - .
#1 - distinct moving - - 48 - 2nd .
#2 - very few motionless - - 48 - - - .
#5 - abundant live - - 48 - decomposing.
#1 2 3 - distinct increasing number of - - 120 - 5th Nov
but no change or decomposition visible in #3 and 4
#3 - first appearance of bacteria after 144 - 6th Nov
#4 first showed a few bacteria with the highest power on the 9th Nov after 216 hours (9 days) and from day to day subsequently slow increase in the number was visible, with corresponding cloudiness in the solution.

Took a small quantity of finely chopped hay and left it for 24 hours soaking in a testtube of gasolene. Then I emptied gasolene from testtube and refilled it with distilled water, on the 1st November. A slight film of gasolene about 1/8" deep remained on the surface of the water. This was set aside to see if microbes would develop.

No bacteria were visible after 96 hours on the 5th
& few bacteria were visible after 29 days.

It was ascertained that dead bacteria do stain in aniline dyes but not so readily as when living

To ascertain the retarding influence of gasolene vapor placed some boiled urine subsequently exposed to air in a testtube within a florence flask at the bottom of which was found some gasolene. The cork of the flask was sealed. This was set aside on the 2nd November.
Up to the 20th no clouding of the urine has been visible

This experiment was repeated on the 8th with fresh urine in a test tube similarly suspended.
Up to the 20th the urine remains perfectly clear.
A similar testtube left unprotected, became cloudy and swarmed with bacteria next day.

On the 3rd November five drops of decomposing urine were added to a test tube containing some fresh urine, to the whole was then added an equal bulk of gasolene. On the 5th no perceptible microbe increase was visible. Up to the 10th very slight increase was visible.

Meter Experiments contd:-

November 20th Tuesday

Measured the resistances of the various bottles as follows:-

No. of bottle	Date & time of obs	Date of setting up	Days since set up	Solution	Surfaces	Res: obs (leads deducted)	Temp:	Current	
VI	8.40. 20.11.88	31.10.88	20	heated	plain varnished	2.62	18.4°C	1 m: amp	
VII		31.10.88	20	not heated	- -	46.0			
XIV		9.11.88	11	- -	varnished	12.84			
XV		9.11.88	11	- -	-	51.0			
XVII		19.11.88	1	heated	plain varnish	2.23			
XVIII		19.11.88	1	-	- -	2.83			
XX		19.11.88	1	-	- -	2.23			
XXII		19.11.88	1	not heated	- -	2.23			
XXIV		19.11.88	1	not heated	- -	3.64			
XXV		19.11.88	1	heated	- -	4.84			
XXVI		19.11.88	1	-	- -	5.04			
XXVII		19.11.88	1	-	- -	11.44.			

Nos. XVII to XXI inclusive were heated by interrupting the meter current temporarily and measuring the resistance quickly with 1 m: amp.

The bottles XXIV, XXV, XXVI, and XXVII were made up on the evening of the 19th Nov: as follows:-

XXIV a 12lt bottle plates already used, cleaned and amalgamated, set up without heating in the usual way

XXV a similar 12 lt bottle made up in usual way except that temp: was brought up in sand-bath to 92°c. and when cool the plates were inserted.

XXVII A similar 12 lt bottle heated to 92°c but with the zincs immersed during the heating. Bubbles formed on these zincs during the process of heating.

XXVI A similar 12 lt bottle heated to 92°c, and with the zincs separately ~~heated in air to about 100°c~~ immersion in the hot solution after it removal from the sandbath.

Two more bottles were made up on the 20th November as follows

XXVIII a 25 lt bottle raised to 90°c with plates unvarnished but amalgamated raised separately in air to 90°c and immersed in the bottle solution on removal of bottle from sand bath.

XXIX a 25 lt bottle raised to 90°c with unvarnished amalgamated plates immersed during the process.

XXX a 12 lt bottle set up to test varnish only. The plates were varnished with Fessenden's insulating material dissolved in $CHCl_3$ the resistance at 20° was observed to be 3.37. It was then raised to boiling point in a sandbath and after cooling (the temperature was allowed to fall slowly) the resistance was:- 4.45.

Gasoline Experiments cont.

Two earthworms were enclosed in a testtube of distilled water after being carefully washed and a layer about 1" deep of gasoline poured on top. The cork was then sealed on the 10th November. After 48 hours incipient decomposition was visible. On the 13th they floated to the bounding surface of the liquids having distinctly decomposed. Microscopic examination then revealed bacteria in the water in large numbers.

Up to 11th Dec: no clouding visible in the urines contained in the florence flasks alluded to on page 340. Both remain quite clear.

On the 12th Nov. a small quantity of fresh earth was introduced into a testtube filled with gasoline above it. After this remained for 24 hours, the gasoline was poured off and replaced by fresh water from the tap.
On the 20th Nov. this water on examination showed a few bacteria (obviously greatly retarded by the presence of the gasoline.
On the 11th Dec. there were present numerous bacteria in sporadic condition.

The following experiment was commenced with caustic potash on the 9th November. Added certain definite weight of pure caustic potash to test tubes of fresh urine.

No 1. contained 6½% KHO.
" 2 " 12½ " " .
" 3 " 25 " " .
" 4 " 0 % " plain urine.

} These were sealed + set aside.

On the 12th bacteria were found in specimens of #4.
none in nos 1, 2, or 3.
On the 14th numerous bacteria in #4, none in the others.
On the 11th Dec: " " " " " " "
Daily examination of specimens from these tubes which had to be exposed to the air on each occasion for that purpose shews that the dissolved KHO. has imparted immunity from bacterial life to the urine up to date.

The following experiment was commenced with sesquichloride of iron Fe_2Cl_6 in solution on the 23rd November. Added ~~[illegible]~~ definite weight of the red crystal Fe_2Cl_6 to freshly voided urine as follows.

No 1. contained 1% Fe_2Cl_6
2 " 2% " "
3 " 4% " "
4 " 8% " "
5 " 16% " "

} These were sealed + set aside

On the 23rd, tubes were found to be all clear, no bacteria visible on examination.
On the 24th, same result.
On the 11th December examination showed no bacteria and certainly no live bacteria in the 1% solution. All clear and no change in the odor. It is certain therefore that up to date the amount of 1% of this salt has prevented decomposition in urine sealed but daily exposed for a few moments to air.
Up to the 31st December only no 1. was found to contain bacteria.

Meter Experiments contd: November 21st Wednesday.

The resistance of the various bottles was measured at 8.30 as follows

The 12 bottles	Date of making up	Temp at Nett	Plates Size	Solution	Plates	Res. when first heated	Res. now observed.	Varnish	Temp.	Current
XI	31.10.88	21	25	heated to 90°	immersed at 8°	8.25° 9.11.88	2.7	rude	16.2°C	1 ma.
XII	31.10.88	21	25	not heated	—	Temp. 9.11.88	50.	"	-	.
XV	9.11.88	12	25	not heated	.	8.20 24° 19.11.88	17.	back crime	-	.
XI	9.11.88	12	25	not heated	-	30.00 24° 19.11.88	56.	- .	-	.
XVII	19.11.88	2	25	heated to 92°	immersed at 90°	2.23 @ 18° 20.11.88	2.0	rude	std. meter #1	.
XVIII	19.11.88	2	25	- . .	- -	2.30 @ 18° 20.11.88	2.25	-	std. meter #2	-
XIX	19.11.88	2	25	- - -	- - -	2.23 @ 18° 20.11.88	2.0	-	Meter #2	-
XXI	19.11.88	2	25	- - -	- - -	2nd taken	2.70	-	Meter #1	.
XXII	19.11.88	2	25	not heated	———	2.23 @ 18° 20.11.88	2.73	-	Meter # 2	-
XXIII	19.11.88	2	25	- -	———	not taken	2.45	.	Meter # 1	-
XXIV	20.11.88	1	12	- -	-	3.6 @ 18° 20.11.88	3.55	-	16.2°C.	-
XXV	20.11.88	1	12	heated to 98	immersed cleaned	4.10 @ 18° . . .	4.65	-	- .	.
XXVI	20.11.88	1	12	- . 92°	immersed hot	5.00 @ 18° . .	4.60	-	- .	.
XXVII	20.11.88	1	12	- . 90°	heated in sol.	11.44 @ 18° . .	11.85	-	- .	.
XXVIII	20.11.88	1	25	- - -	heated in air	——	7.45	-	- .	—
XXIX	20.11.88	1	25	- - -	heated in sol.	——	2.85	-	- .	.
XXX	20.11.88	1	12	varnish	not - - .	3.37 @ 18° . .	4.45	-	- .	.

Took one of the 12lt bottles made up on the 5th October which has been set aside inactively since that date (47 days) its resistance at 17°C was observed to be 67.0 w. The bottle was then heated as it stood on a sandbath to boiling point. The res: when hot perhaps 90° was still 59 w. but after cooling fell to 55 w.

November 22nd Thursday

Made up 4 25 lt bottles @ follows

XXXI was set up with ordinary city water from the tap, & heated to 90°C. with the amalgamated zincs in it.

XXXII was similarly set up but not heated.

XXXIII was similarly set up but the zincs were separately heated in $ZnSO_4$ solution to 100°C and then immersed in the bottle while still hot.

XXXIV was set up with Chapman c.p. solution made from distilled water in the ordinary way and not heated

XXXV - - - with c.p. $ZnSO_4$ solution and heated to 90°C.

Taking any three equations for separate solution such as

(1) $a + 2.4b + 5.76c = 2.4474$

(2) $a + 4.13b + 16.81c = 2.485$

(3) $a + 15.8b + 249.6c = 1.000$

by (1) $a = -2.4b - 5.76c + 2.4474$

(2) $-2.4b - 5.76c + 2.4474 + 4.13b + 16.81c = 2.485$
$+ 1.7b + 11.05c = -1.989$

(3) $-2.4b - 5.76c + 2.4474 + 15.8b + 249.6c = 1.000$
$+ 13.4b + 243.88c = -3.4474$

(2) $b = \frac{-11.05c}{1.7} - \frac{1.989}{1.7}$
$= -6.5c - 1.17$

(3) $-13.4 \times 6.5c - 13.4 \times 1.17 + 243.88c = -3.4474$
$-87.1c - 15.68 + 243.88c = -3.4474$
$156.78c = 12.206$
$c = 0.0779$

$b = -6.5 \times 0.0779 - 1.17$
$= -0.506 - 1.17$
$= -1.676$

$a = 2.485 + 4.13 \times 1.676 - 16.81 \times 0.0779$
$= 2.485 + 6.922 - 1.309$
$= 8.098$

$8.098 + 2.4 \times -1.676 + 5.76 \times 0.0779 =$
$= 4.022 + 0.449 = 4.475$

No. of equat.	Residual v	Residual squared v^2	Σv^2	$\frac{0.6745}{\sqrt{n-1}}$	$\sqrt{\Sigma v^2}$	$0.6745\sqrt{\frac{\Sigma v^2}{n-1}}$	$0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$	$0.6745\sqrt{\frac{\Sigma v^2}{n(n-3)}}$	Σv
1	−0.69	0.4761							
2	+0.50	0.2500							
3	+0.88	0.7744							+ 1.81
4	+0.02	0.0004							
5	−0.36	0.1296	2.2191	0.2894	1.49	0.584	0.4278	0.192	
6	−0.59	0.3481							
7	−0.17	0.0289							
8	+0.46	0.2116							− 1.83
									3.64 ÷ 8 = 0.4468

The probable error of any observed sp. res. varying between 13 and 34 with a mean of 23.5 say is 0.581 or 2.5%

and the equation for the parabola is $37.99 - 0.9313t + 0.0088t^2 \pm 0.190$

Resistances of $ZnSO_4$ solution and temp. coeff. continued. from p. 23.

Taking the equations on p. 23 with the values $a = 3.8114$ $b = -0.219$ $c = 0.00287$ we have.

0.511	$a + 20.7b + 428.5c$	$= 0.924$	(1)	$3.8114 - 4.533 + 1.230 - 0.924$	$= -0.413$
0.814	$a + 17.9b + 320.4c$	$= 1.003$	(2)	$3.8114 - 3.920 + 0.920 - 1.003$	$= -0.189$
1.132	$a + 14.8b + 219.5c$	$= 1.073$	(3)	$3.8114 - 3.241 + 0.629 - 1.073$	$= +0.129$
1.645	$a + 11.7b + 136.9c$	$= 1.218$	(4)	$3.8114 - 2.562 + 0.393 - 1.218$	$= +0.427$
2.263	$a + 7.9b + 62.4c$	$= 1.581$	(5)	$3.8114 - 1.730 + 0.179 - 1.581$	$= +0.722$
2.984	$a + 4.1b + 16.8c$	$= 2.485$	(6)	$3.8114 - 0.898 + 0.028 - 2.485$	$= +0.479$
3.305	$a + 2.4b + 5.8c$	$= 4.4474$	(7)	$3.8114 - 0.526 + 0.017 - 4.4474$	$= -1.169$
1.070	$a + 15.8b + 249.6c$	$= 1.000$	(8)	$3.8114 - 3.460 + 0.716 - 1.000$	$= +0.070$

No. of equat.	Residual v	v^2	Σv^2	$\frac{0.6745}{\sqrt{n-1}}$	$\sqrt{\Sigma v^2}$	$0.6745\sqrt{\frac{\Sigma v^2}{n-1}}$	$0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$			
1	−0.413	0.1706								
2	−0.189	0.0357								
3	+0.129	0.0166								
4	+0.427	0.1823	2.5297	0.2549	1.59	0.2549 × 0.2249 = 0.4053	0.0901 × 1.59 = 0.1433			
5	+0.722	0.5213								
6	+0.479	0.2294								
7	−1.169	1.3669								
8	+0.070	0.0049								
	3.598									

The table shows that the curve is not a parabola.

The following table presents Euring and MacGregor's results @ 10°C

No.	Density	% of Anhydrous $ZnSO_4$	sp. res. ρ_t	sp. res. ρ_{18}	calculated by formula	Ratio k that of 1:185 18	No.	Density	% of Anhydrous $ZnSO_4$	sp. res. ρ_t	sp. res. ρ_{18}	calculated by formula	Ratio k that of 1:185 18
1	1.0140	1.4	182.9			5.70	11	1.2709	22.6	32.2	28.5	27.9	0.888
2	1.0187	1.8	140.5			4.38	12	1.2891	24.0	29.9	28.3	27.9	0.882
3	1.0278	2.7	110	111.1	12.7	3.46	13	1.2895	24.0	32.2	28.5	27.9	0.888
4	1.0540	5.0	63.1	63.8	65.2	1.99	14	1.2987	24.3	32.2	28.7	27.9	0.894
5	1.0760	7.0	50.1	50.8	48.8	1.58	15	1.3288	26.5	29.9	29.2	28.1	0.910
6	1.1019	9.5	40.6	42.1	40.0	1.31	16	1.3530	28.1	34.7	31.0	28.8	0.966
7	1.1582	14.2	33.3	33.7	32.0	1.05	17	1.4053	31.36	34.7	32.0	33.5	1.000
8	1.1845	16.2	31.5	32.1	29.3	1.00	18	1.4174	32.0	33.0	33.4		1.040
9	1.2186	18.6	30.0	30.3	28.1	0.944	19	1.4220	33.0	33.3	33.7		1.050
10	1.2562	21.5	29.3	29.2	28.1	0.910	20						

Taking the equations from page 2 and the values $a = 37.99$ $b = -0.9313$ $c = +0.0088$

$a + 5b + 25c$	$= 34.26$	$37.99 - 4.66\frac{1}{2} + 0.22$	$= 33.55$	-0.69
$a + 12.5b + 156.3c$	$= 27.23$	$37.99 - 11.64 + 1.38$	$= 27.73$	$+0.50$
$a + 16.1b + 259.2c$	$= 24.39$	$37.99 - 15.00 + 2.28$	$= 25.27$	$+0.88$
$a + 24.4b + 697c$	$= 19.51$	$37.99 - 24.89 + 6.13$	$= 19.53$	$+0.02$
$a + 32.1b + 1030.4c$	$= 17.52$	$37.99 - 29.90 + 9.07$	$= 17.16$	-0.36
$a + 39.2b + 1536.6c$	$= 15.61$	$37.99 - 36.51 + 13.53$	$= 15.02$	-0.59
$a + 45.5b + 2070.3c$	$= 14.00$	$37.99 - 42.38 + 18.22$	$= 13.83$	-0.17
$a + 52.2b + 2724.8c$	$= 12.88$	$37.99 - 48.62 + 23.97$	$= 13.34$	$+0.46$

Rule for determining the specific resistance of any solution density of zinc sulphate — Find the density at 20°C with this from the table or curve find the coefficient k. The spec. res. will then be at the temp of t°C.

$k\,(37.99 - 0.9313t + 0.0088t^2)$

Meter Experiment contd
November 22nd Thursday

Took resistance of bottles as follows —

No. of bottle	Date of setting up	Days elapsed	Size of Plates	Solution	varnish	Plates	Res. when first tested	Res. now observed	Temp.	Current
XVI	31.10	22	25"	heated to 81°	roots only	immersed at 80°	2.5 on 23° 9.11.88	1.99	21.2°C	1 mono
XVII	31.10.	22	25"	not heated	- - -	—	7.1 on 23° . . .	39.	-	-
XIV	9.11	13	25"	- -	backs varnish	—	5.2 on 23° 19.11.88	16.74	-	-
XV	9.11	13	25"	- -	backs varnish	—	4.00 23° 19.11.88	46.	-	-
XVIII	19.11	3	25"	heated to 90°	roots only	immersed at 90°	2.23 on 18° 20.11.88	1.74	Old meter #1	-
XVIII	19.11	3	25"	- - -	- -	- - -	2.23 on 18° 20.11.88	1.94	Old Meter #2	-
XX	19.11	3	25"	- - -	- -	- - -	2.23 on 18° 20.11.88	1.84	Meter #2	-
XXI	19.11	3	25"	- - -	- -	- - -	2.23 on 18° 20.11.88	2.44	Meter #1	-
XXV	19.11	3	25"	not heated	- -	—	2.23 on 18° 20.11.88	2.49	Meter #2	-
XXIII	19.11	3	25"	- -	- -	—	2.25 on 18° 20.11.88	2.44	Meter #1	-
XXII	20.11	2	12	- -	- -	—	3.64 on 18° 21.11.88	2.99	24.2°C	-
XXV	20.11	2	12	heated to 90°	- -	immersed when hot	4.34 on 18° 21.11.88	3.84	-	-
XXVI	20.11	2	12	- -	- -	immersed hot	5.04 on 18° 21.11.88	3.99	-	-
XXVII	20.11	2	12	- - -	- -	heated in sol.	11.44 on 18° 21.11.88	7.44	-	-
XXVIII	20.11	2	25"	- - -	- -	heated in air.	7.45 on 18° 21.11.88	4.44	-	-
XXIX	20.11	2	25"	- - -	- -	heated in sol.	2.55 on 18° 21.11.88	1.94	-	-
XXX	20.11	2	12	varnish hot	backs varnish	- - -	4.45 on 18° 21.11.88	3.24	-	-

November 23rd Friday

No XXXVI was made with zincs amalgamated for the third time but not amalgamated, distilled mercury and chemical room solution heated with the zincs in place to 90°C. The zinc electrodes were coated with collodion varnish.

No XXXVII was made as above but without heating the solution zincs which were inserted in the solution after heating and when still hot

No. XXXVIII plain new zincs cleaned not filed not amalgamated in chemical room solution not heated

No XXXIX same as last (XXXVIII) but solution heated with zincs in place to 90°C.

No XL Amalgamated unvarnished zincs same treatment as XXXVII except that solution heated more rapidly.

XL I
XL II
XL III } varnish test.

a quantity of mercury was distilled for amalgamation

November 24th Friday

Found the resistances of all the bottles made on the previous day abnormally high. Took them all down and made up 3 more without rubber connections and with the zincs only 2 pots immersed on the ground that either the unvarnished copper or the rubber might possibly have some bearing on the results.

XL IV Amalgamated zincs. Chemical room solution heated to 70° and zincs then inserted.

XL V Amalgamated zincs. Chemical room solution heated to 80° and zincs then inserted

XL VI Amalgamated zincs. Chemical room solution heated to 90° and zincs then inserted.

Table showing behavior of the resistance of bottles.

No of bottle	Date of Inspection	Varnish	Solution	Plates removed or not	Surface Weak	19.11.98 26.0°	20.11.98 19.0°	21.11.98 16.5°	22.11.98 20.5°	23.11.98 20.5°	24.11.98 21°	26.11.98 21°	27.11.98 25.5°	28.11.98 26.5°	30.11.98 23.5°	1.12.98 21°	3.12.98 20.5°	5.12.98 18.5°	6.12.98 24.5°	11.12.98 27°	14.12.98 26.5°	22.12.98 22°			
VI 25	31. 10.98	Nordo	heated to 80°	after cooling	2.8 mm 18.11.98	1.8	2.6	2.7	1.99	2.75	1.95	1.60	1.30	1.25	1.35	1.45	1.35	2.05	1.05	1.00	0.88	0.92			
VII 25	31. 10.98	Nordo	not heated	—	7.1.25° 18.11.98	30.0	40.0	50.0	39	50.	40.	37.	31.0	30.0	36.	40.	44.	50	40	20	42.	50			
VIII 25	9. 11.98	Nordo varnish	not heated	—	8.2.25° 19.11.98	3.2	12.2	7.0	16.7	23.25	16.75	16.75	15.95	15.75	14.75	22.75	22.25	24.	19.5	17.25	20.25	28			
IX 25	9. 11.98	Nordo varnish	not heated	—	30.2.25° 19.11.98	30.0	51.0	56.0	44.	55.	24.25	27.	23.	23.	16.	50	52.	34.	22.5	22.25	26.75	30			
X 25	14. 11.98	Nordo	heated 100°	after cooling	2.2.25° 18.11.98		2.2	2.0	1.74	2.00	1.60	1.55	1.15												
XI 25	14. 11.98	Nordo	heated 100°	after cooling	2.2.25° 18.11.98		2.8	2.25	1.94	1.95	1.40	1.45	1.15												
XII 25	14. 11.98	Nordo	heated 100°	after cooling	2.2.25° 18.11.98		2.2	2.0	1.84	2.10	1.65	1.60	1.25												
XIII 25	14. 11.98	Nordo	heated 100°	after cooling	2.7 7° 20.11.98		2.09	2.70	2.44	2.15	2.05	2.00	1.65												
XIV 25	14. 11.98	Nordo	heated 100°	after cooling	2.25 1° 20.11.98	1.16	2.2	2.70	2.09	2.10		2.05	1.35												
XV 25	14. 11.98	Nordo	not heated	—	2.25 7° 20.11.98	1.24		2.65	2.66	2.25		2.00	1.75												
XVI 25	20. 11.98	Nordo	not heated	—	3.64 1° 20.11.98		3.64	3.55	2.99	3.25		2.50	2.15	2.25	2.55	2.75	2.75	3.20	2.95	2.75	2.95	3.35			
XVII 25	20. 11.98	Nordo	heated 100°	after cooling	2.25 18° 20.11.98		2.24	2.60	3.80	2.25		2.65	2.35	2.25	2.70	2.55	3.45	3.45	3.05	3.25	10.75	37			
XVIII 25	20. 11.98	Nordo	heated 100°	after cooling	2.25 15° 20.11.98		2.24	2.60	3.99	2.95		3.65	2.55	2.75	2.55	2.75	3.05	3.35	2.05	14.25	14	100			
XIX 25	20. 11.98	Nordo	heated 100°	heated in bottle	2.25 12° 20.11.98		11.24	10.82	7.24	3.35		2.05	3.25	3.75	2.15	2.45	5.75	7.25	7.95	14.25	26	95			
XX 25	20. 11.98	Nordo	heated 100°	heated in bottle	7.25 15° 20.11.98			7.24	2.24	2.30	3.55	1.95	1.80	1.90	2.55	2.65	3.25	4.75	5.35	15.25	22				
XXI 25	20. 11.98	Nordo	heated 100°	heated in bottle	2.25 15° 20.11.98			2.25	1.94	2.10	1.75	1.80	1.60	1.65	2.05	2.35	2.95	4.25	7.15	12.75	20				
XXII 25	22. 11.98	varnish	not heated	—	7.75 15° 23.11.98					7.75	7.45	9.25	7.75	8.35	6.75	6.45	3.65	5.75	6.65	7.75	10.0	14			
XXIII 25	22. 11.98	varnish	not heated	—	6.55 15° 23.11.98					6.25	10.15	8.75	6.75	6.15	11.55	16.75	20.0	26.	12.25	11.75	17.75	20			
XXIV 25	22. 11.98	varnish	not heated	heated in water bath	5.55 15° 23.11.98					5.55	15.75	22.75	10.75	10.65	15.75	23.25	24.	32.	22.	22.	29.25	26			
XXV 25	22. 11.98	varnish	heated to 90°	heated in bottle	5.05 15° 23.11.98					5.05	2.00	1.65	2.15	1.50	1.95	2.25	2.95	5.75	15.25	29.25	43				
XXVI 25	22. 11.98	varnish	heated to 90°	heated in bottle	4.95 15° 23.11.98					4.95	5.50	7.55	5.15	3.65	4.25	5.15	4.45	4.95	3.45	2.95	3.25				
XXVII 25	22. 11.98	non varnish	heated to 90°	after heating	3.25 25° 24.11.98					3.25	2.85	1.95	1.75	1.65	1.80	2.75	2.85	16.85							
XXVIII 25	22. 11.98	- - -	heated to 90°	after heating	2.55 25° 24.11.98					2.55	2.10	2.05	2.00	1.90	2.25	2.25	2.25	2.25							
XXIX 25	22. 11.98	- - -	heated to 90°	after heating	2.25 25° 24.11.98					2.25	1.95	1.75	1.65	1.80	1.95	1.75	2.25								
XXX 25	22. 11.98	nordo	heated to 100°	after heating	1.75 25° 24.11.98							1.75	1.30	1.05	2.05	1.85	1.65	0.95	0.80	0.75	3.20				
XXXI 25	22. 11.98	nordo	heated to 100°	—	3.25 25° 24.11.98							3.25	3.50	3.00	—	—	—								
XXXII 25	22. 11.98	nordo	heated to 100°	—	2.95 25° 24.11.98								2.95	2.05	3.25	2.35	2.25	2.05	2.15	11.75	25				
L 25	30. 11.98	nordo	heated to 100°	—	1.95 26° 28.11.98								1.95	1.50	1.65	1.55	1.55	1.25	1.15	1.65	3.25				
LI 25	30. 11.98	nordo	- - -	- - -	1.95 26° 28.11.98								1.95	2.65	2.45	2.65	2.55								
LII 25	30. 11.98	nordo	- - -	- - -	1.65 26° 28.11.98								1.65	1.90	1.95	2.30	2.30	1.75							
LIII 25	30. 11.98	nordo	- - -	- - -	1.60 26° 28.11.98								1.60	1.85	1.95	2.15	2.25	1.75							
LIV 25	23. 11.98 heated	nordo	not heated	commencing	4.11 24° 25.11.98								4.11	2.65	2.25	2.75	2.65	2.10							
LV 25	23. 11.98	nordo	- -	- - -	3.05 24° 25.11.98								3.05	2.25	3.15	3.45	2.85	2.15							
LVI 25	23. 11.98	nordo	- -	- - -	5.00 24° 25.11.98								5.00	2.85	3.25	5.20	2.85	1.35							
LVII 25	23. 11.98	nordo	- -	- - -	1.60 24° 25.11.98								1.60	1.55	1.65	1.65	2.25	1.75							
LVIII 25	5. 12.98	nordo	heated to 100°	not heated	14.45 24° 6.12.98													14.45	2.0						
LIX 25	5. 12.98	nordo	- - -	5% by weight	2.05 24° 6.12.98													2.05	1.12	2.25	4.25				
LX 25	5. 12.98	nordo	- - -	5% by weight	9.05 24° 6.12.98													9.05	3.32	2.85	3.05				
LXI 25	5. 12.98	nordo	- - -	5% by weight	2.95 24° 6.12.98													2.95	1.22	2.95					
LXII 25	5. 12.98	nordo varnish	- - -	5% heated to 100°	4.95 24° 6.12.98													4.95	3.85	6.75	50				
LXIII 25	5. 12.98	nordo varnish	- - -	5% heated to 100°	3.45 24° 6.12.98													3.45							
LXIV 25	5. 12.98	nordo varnish	- - -	5% heated to 100°	5.25 24° 6.12.98													5.25							

Phonograph battery tests.

The trials of the new pattern of Chromic acid battery were made as follows:-

On November 15th Two cells of size as described on page 10 were fitted with pressed Gravit carbons in plate form instead of the previous arc carbons. The curves obtained from the observation of their performance on that date were preserved. The EMF being rather low, another trial was made on the following day (16th) with real Gravit cut carbons, and the results are shewn in the subjoined table as Line III. The curve is recorded on the same sheet as that giving I and II. Lastly the zincs having been reduced in dimensions to 5cms X 12.7 X 1 cm another run was made on the 20th the main facts relating to which are stated on line IV. The curve pertaining to this was also preserved.

No.	Date	Style of Cell	at 2 Amt EMF	I.R.	C.	after 6 hours EMF	I.R.	C	after 12 hours EMF	I.R.	C.
I & II	15.11.88		1.98	0.04	3.7	1.88	0.07	3.2	1.78	0.12	2.9
III	16.11.88		1.97	0.058	3.5	1.88	0.07	3.2			
IV			2.025	0.062	3.55	1.88	0.07	3.25	1.82	0.13	2.95
V											

Meter Experiments contd.

November 26th Monday.

Two more solutions made up as follows:-

XLVII Two previously used 25 zinc plates reamalgamated in the usual way and heated in bottle of chemical room solution to 90°C on sand bath. Zincs varnished but tops out of liquid.

XLVIII Two previously used 25 zinc plates reamalgamated after heating in incubator to about 100°C, i.e. amalgamated hot. and again heated in similar o.r. solution to 100°C.

Since both these pairs of zinc plates lost their lustre after the heating of the bottles they were removed while the liquid was still hot and reamalgamated and then quickly replaced. They then retained their metallic lustre and accumulated bubbles on their surface.

Meter Experiment November 27th Tuesday.

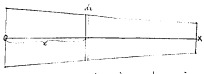
Two more solutions made up as follows:-

XLIX Two 25 zinc plates, old and well worn from commercial use were amalgamated then heated to 100°C in $ZnSO_4$ solution & reamalgamated. They were then immersed in solution that had been heated to 100°C and cooled.

~~XL~~ L Two new 25 zinc plates other particulars and treatment same as last XLIX

Problem.

To find the resistance of a homogeneous solid conductor in the form of a right conic frustum between the terminal circular surfaces, having given the specific resistance of the material, the length of the axis and the terminal radii.



Let O be the centre of one of the terminal circles and the origin of coordinates, OX the length of the frustum

ρ = the radius at any point

ρ = the spec: res: of the material

x = any distance from O measured along OX

Then the resistance dR of any elementary lamina is

$$dR = \frac{\rho\,dx}{\pi\rho^2} \quad \text{but } r = f(x) = ax + b \text{ suppose}$$

Then $dR = \dfrac{\rho\,dx}{\pi(ax+b)^2}$

Thus $R = \int_0^X \dfrac{\rho\,dx}{\pi(ax+b)^2} = -\dfrac{\rho}{\pi}\left\{\dfrac{1}{a(aX+b)} - \dfrac{1}{a(a\times 0+b)}\right\}$

$$= \frac{\rho}{\pi} \times \frac{aX}{b(aX+b)} = \frac{\rho}{\pi}\frac{X}{b\,r_2} = \frac{\rho X}{\pi(r_2 r_1)}$$

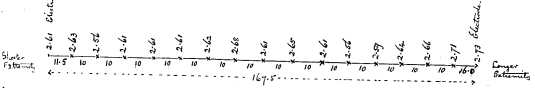
so that instead of taking the arithmetical means of the terminal radii for the radius of the mean area, the geometrical mean is mathematically the correct one.

Specific Resistance and Temp: Coeff: of $ZnSO_4$ solution contd.

(4/6)

Since it might be possible to question the accuracy of the spec: res: obtained on the ground that the mean area of the tube employed was not determined with sufficient accuracy, I took it down and measured its diameter at every 10 cms: in the following way.

A glass tube about 15 cms in diam: and some 150 cms long was supported on a temporary pivot at its centre of length and its two ends were fitted with corks. One end carried in the cork a vertical wire 2·42 cms by scale and 2·408 by micrometer length say 2·4112 or 2·4112 ± 0·0027. At the other end a pin issuing horizontally from the cork moved by the side of a vertical cm: scale. The tube to be tested was passed over the first end of this measuring tube and the free vertical play of the wire end was measured by the corresponding movement of the pin over the scale. The following diagram represents the diameter thus found.



Assuming there a series of conic frustra we have

$$R = \frac{\rho}{\pi}\left\{\frac{l_1}{r_1 r_2} + \frac{l_2}{r_2 r_3} + \frac{l_3}{r_3 r_4} + \qquad + \frac{l_n}{r_n r_1}\right\} = \frac{\rho\, l}{\pi\, \bar{\sigma}^2}$$

$$\therefore \pi\sigma^2 = \frac{\frac{1}{2}\pi l}{\frac{l_1}{r_1 r_2} + \frac{l_2}{r_2 r_3} + \frac{l_3}{r_3 r_4} + \qquad + \frac{l_n}{r_n r_1}}$$

No. of section	l	d	d_1	$\frac{l}{r_1 r_2}$	$\Sigma \frac{l}{r_1 r_2}$	No. of section	l	r	r_1	$\frac{l}{r_1 r_2}$	$\Sigma \frac{l}{r_1 r_2}$
1	11·5	2·61	6·862	1·676		9	10	2·61	6·915	1·4466	
2	10	2·63	6·732	1·485		10	10	2·65	6·915	1·4466	
3	10	2·56	6·682	1·497		11	10	2·61	6·681	1·497	
4	10	2·61	6·812	1·468		12	10	2·56	6·630	1·508	
5	10	2·61	6·812	1·468		13	10	2·59	6·837	1·462	
6	10	2·61	6·837	1·462		14	10	2·64	7·024	1·425	
7	10	2·62	7·020	1·425		15	10	2·66	7·268	1·387	
8	10	2·68	6·994	1·429	11·99 Ω	16	16·0	2·71	7·398	2·1632	12·39 Ω
	51·5	2·61	6·812				56·0	2·72			
											24·24

$$\frac{\cancel{\pi} \times 3{\cdot}14416 \times 167{\cdot}5}{4 \times 24{\cdot}24} = \frac{526{\cdot}2}{96{\cdot}96} = 5{\cdot}427 \text{ sq cms mean area.}$$

The result agrees with the previously accepted one to within 1%.

To take it would seem to reduce the calculated spec: res: under 1%.

Meter Experiments contd:— November 27th Tuesday

Took down meter bottles which have been at work since the 19th and weighed plates

Bottle	Position	Air-bag	Plate	Weight simply	Sample weight	Weight 19.11.11	Gain	Loss	Loss corrected for blank	Ratio of Gain/Loss	% error	Average % Error
XVII	Standard #1		1	85·1812	0.1236	85·6353						
			2	90·2747	175·4276 / 175·4702	89·8347	0·4400	0·4541 / 0·1141	0·4566	1·0013		
XVIII	Standard #2		3	88·1450	177·8267	88·9013						
			4	89·3447	177·8107 / 0·1106	88·9254	0·4393	0·4563 / 0·1198	0·4572			
XIX	Conf. Standard		5	81·1333	169·1270	81·1425						
			6	88·0242	169·1585 / 168·0882	88·0444	0·	0·0092 / 0·2293 / 0·2293	0·2293			
XX	Meter #2 A warm		7	81·4320	172·0913	81·8796						
			8	90·6536	172·0886 / 0·0226	90·2112	0·4422	0·4456 / 0·0324		(1·026 / 0·978)	2·5% warm + heated	1·65
XXI	Meter #1 A cold		9	88·6088	178·1460	89·0541						
			10	89·8336	178·1358 / 0·1105	89·3920	0·4415	0·4533 / 0·1173		(1·008 / 0·992)	0·8% cold + heated	1·37
XXII	Meter #2 B warm		11	91·1769	180·2741	91·6107						
			12	89·0660	180·2428 / 0·0298	88·6418	0·4242	0·4348 / 0·1106		(1·051 / 0·951)	4·9% warm + not heated	1·8
XXIII	Meter #1 B cold		13	87·1940	169·2161	87·6482						3·85
			14	82·0556	169·2102 / 0·0059	81·5681	0·4475	0·4442		(1·029 / 0·972)	2·8% cold + not heated	

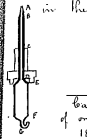
November 28th Wednesday

Mr West having brought with him 6 bottles that had been set up commercially at Pearl St., the meter test was commenced with them and the standards at 10 o'clock, some 50 hours after the Pearl St bottles had been set up.

Bottle	Position	Plates	Solution	Weight simply	Sums of samples	Observed wt. of water	Discrepancy	Observer			
I	Conf. Std.	Previously tst	heated	(1) 88·9887 (2) 87·3990	176·3877	176·3887	+0·0010	A.E.K.			
II	Std #1	" -	-	(3) 89·0018 (4) 90·1742	179·1760	179·1750	-0·0010	-			
III	Std #2	- -	-	(5) 89·2789 (6) 84·3411	173·6200	173·6210	+0·0010	-			
IV	Meter #1 cold	Commercially	not heated	(1) 79·310				Pearl St			
V	"	-	- -	(2) 76·400				-			
VI	Meter #2 warm	-	- -	(3) 82·625				-			
VII	- -	-	- -	(3a) 80·010				-			

Experiments on the resistance of zinc sulphate solution

To ascertain whether the resistance of $ZnSO_4$ solution altered under pressure I took the bailliet apparatus and arranged to fill a tube with the solution insert a zinc plated wire in the top and seal them into resistance of column of liquid between the wire and the mercury in the chamber and apply pressure.



Lengths				
Top A to shoulder B internally	5·3	External Diam	1·2	outer tube.
Shoulder B to Collar C .	15·5	Internal -	0·25	
Shoulder B to Shoulder D .	27	External .	2·0	
Shoulder D . . F .	23			
Total length from top A to arm E	57·5			

Calibrations.

of one tube L.C.N. drawn compared with bell tube whose vol: per cm = 0.2662

18 cms of pressure tube equal 4·35 cms of bell tube in capacity = 0·0649 c.c.

17 - - - - - 3·90 . - - - - - - = 0·0619 . .

15·5 - - - - - 3·90 . - - - - - - = 0·0676 . .

15 - - - - - 3·70 . - - - - - - = 0·0662

0·0652

No. of obs.	Obs: from	Mean	Residual	r^2	Σr^2	$\sqrt{\Sigma r^2}$	$0.6745\sqrt{\frac{1}{n(n-1)}}$	γ	Calculated Accu	Diam
1	0·0649	0·0652	+0·0003	9.0×10^{-8}	1774×10^{-7}	42.1×10^{-4}	0·1947	0·00082	0·0652 ±	±288
2	0·0619		+0·0033	109.9×10^{-8}					0·0001	
3	0·0676		-0·0024	576×10^{-8}		0·0042				
4	0·0662		-0·0010	100×10^{-8}						

The first test was made on the 24th Nov: when however no very accurate readings could be obtained. About 20 cms: of the fine tube contained $ZnSO_4$ solution having a density of 1·18 @ 20°. Its spec: res: being about 230 the res: of this column would be $\frac{23 \times 230}{0.065}$ or 7076 and the actual res: observed was about 8000 Ω. On applying pressure, the res: fell rapidly and after about 100 atmosphere was reached the res: was about 6000 Ω, a fall of 25%. There was however air in the tube, perhaps 1 c.c. above the liquid column, and the heat generated by the pressure and condensation of this would probably account for the great diminution. The seal gave way at 180 atmosphere. The next test took place with the same tube on the same day. The seal of the electrode was this time so contrived that no air remained imprisoned. The following results were obtained with about 20 cms: of the same solution calculated to give about 7080 Ω.

No. of Pt	Time	Current thro test tube	Res: obsd	Pressure	Temp: air	Press: in atmospheres	Δr	Δz	Δr/Δz	
1	21.30	1 ma	6970	1 atm	20°	1.01	15	4.04	3.71	
2			6955	5		5.05	5	7.07	0.71	
3			6950	12		12.12				
4			6940	25		25.25	10	13.	0.77	
5			6935	36		36.36	5	11	0.45	
6			6932	50		50.5	3	14	0.21	

Experiments on the resistance of zinc sulphate solution under

These experiments were continued on the 30th November as follows—

The Bunsen tube was this time exhausted after the plated wire had been sealed in it, and the lower end sealed. The seal was then broken under $ZnSO_4$ solution (pure slightly acid and of sp.g. 1.178 @ 23.6°.C.) The temp. of the water in the press was about 23°.C. When the tube had filled with the solution a little mercury was introduced into the lower bend and the whole steadily forced into the mercury both after a zinc plated and amalgamated platinum wire had been thrust up into the tube almost to the shoulder D. thus leaving a column of about 23 cms. in ext. between the electrodes. This would mean an estimated resistance of 8500 ω, and the observed resistance was about 10,600.

	Bridge	Time	Indicated Pressure	Obd. Res.	Obd. res. for T.B.	Δt	Δp	$\frac{\Delta r}{\Delta p}$	Pressure in atmos.	Corrected value of Δp	Ratio $\frac{r_p}{r_{p'}}$
1	Bridge 10	16.00	1.	10640	10,670				1.01	1	1.0272
2			6	10650	10680				6.06		
3			12	10640	10670				12.12		
4			16	10640	10670				16.16		
5			20	10640	10670				20.2		
6			25	10640	10670				25.25		
7			5	10680	10710	40	−20	−2.0	5.05	−2.0	
8			25	10640	10670				25.25		
9			30	10640	10670				30.3		
10			35	10640	10670				35.35		
11			40	10630	10660				40.4		
12			45	10620	10650						
13			50	10610	10640				45.45		
14									50.5		
15			5	10690	10720	80	−45	−1.8	5.05	−1.8	
16			25	10650	10680	−40	+20	−2.0	25.25		
17			50	10620	10650	−30	+25	−1.2	50.5		
18			55	10610	10640	−10	+5	+2.0	55.5		
19			60	10600	10630	−10	+5	−2.0	60.6		
20		16.15	65	10600	10630				65.7		
21		.16	70	10590	10620				70.7		
22		.18	75	10580	10610				75.8		
23		.18	5	10700	10730	+120	−70	−1.7	5.1	−1.7	
24		.25	5	10790	10820				5.1		
25		30	5	10790	10820				5.1		
26		.30	25	10760	10790	−30	+20	−1.5	25.3	−1.5	
27		.30	55	10710	10740	−50	+30	−1.7	55.6	−1.7	
28		.31	75	10670	10700	−40	+20	−2.0	75.8		
29		.31	85	10650	10680	−20	+10	−2.0	85.9		
30		.31	95	10630	10660	−20	+10	−2.0	96.0		
31		.32	100	10620	10650				101		
32		.33	110	10600	10630				111		
33		.33	120	10590	10620				121		
34		.33	135	10570	10600				136		
35	Bridge $\frac{1000}{100}$	.34	150	10540	10570				152		
36		.34	160	10530	10560				162		
37		.35	170	10510	10540	−280	+165	−1.7	172	−1.7	
		.36	175	Tube seal broke.							

$\frac{EX}{r}$ = 0.73 mutiplied by this pressure tube. T.B. 27.1°

80 mms. giving the bridge coeff. of reduction for bridge $\frac{1000}{100}$

It is evident from these results that the resistance of the column decreased 1·7 in 10700 or 0·00159 % for every additional atmosphere.

If this was due to an enlargement of the glass by the pressure, then $a_p : a :: r_p^2 : r_{p'}^2$

$\therefore 10701.7 : 10700 \quad \therefore r_p = r\sqrt{\frac{10701}{10700}} \quad r\sqrt{1.00001551} \quad r \times 1.000079$ = 0·008 % radial expansion per atmosphere

With a constant friction on the pivots the equation of motion becomes:-

$$\frac{d^2\theta}{dt^2} = -\frac{E\theta}{Mk^2l} \pm \frac{f}{Mk^2}$$

which becomes $\frac{d^2\theta}{dt^2} = -a\theta \pm b$ where $a = \frac{E\theta}{Mk^2l}$ and $b = \frac{f}{Mk^2}$

$$\therefore \quad 2\frac{d\theta}{dt}\frac{d^2\theta}{dt^2} = -2a\theta\frac{d\theta}{dt} - 2b\frac{d\theta}{dt}$$

$$\therefore \quad \left(\frac{d\theta}{dt}\right)^2 = -a\theta^2 - 2b\theta + c \quad \text{where } c \text{ is defined by the condition}$$

That when $\frac{d\theta}{dt} = 0$ $\theta = 0$ and $\theta = \varphi$ the limiting angle

$$\therefore \quad 0 = -a\varphi^2 + c$$

$$\text{or } c = a\varphi^2$$

$$\therefore \quad \left(\frac{d\theta}{dt}\right)^2 = -a\theta^2 - 2b\theta + a\varphi^2$$

$$\text{and } \frac{d\theta}{dt} = \sqrt{a(\varphi^2 - \theta^2) - 2b\theta}$$

$$\therefore \quad dt\frac{dt}{d\theta} = \frac{d\theta}{\sqrt{a\varphi^2 - 2b\theta - a\theta^2}}$$

$$\therefore \quad \int_{-\varphi}^{+\varphi} dt\frac{dt}{d\theta} = \int_{-\varphi}^{+\varphi}\frac{d\theta}{\sqrt{\alpha + 2\beta\theta - \gamma\theta^2}} \quad \text{where } \alpha = a\varphi^2,\ \beta = -b,\ \gamma = a$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\frac{\gamma\varphi - \beta}{\sqrt{\alpha\gamma + \beta^2}} - \sin^{-1}\frac{-\gamma\varphi - \beta}{\sqrt{\alpha\gamma + \beta^2}}\right\}$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\frac{a\varphi + b}{\sqrt{a^2\varphi^2 + b^2}} - \sin^{-1}\frac{-a\varphi + b}{\sqrt{a^2\varphi^2 + b^2}}\right\}$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\sqrt{\frac{a^2\varphi^2 + b^2 + 2ab\varphi}{a^2\varphi^2 + b^2}} - \sin^{-1}\sqrt{\frac{a^2\varphi^2 + b^2 + 2ab\varphi}{a^2\varphi^2 + b^2}}\right\}$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\sqrt{1 + \frac{2ab\varphi}{a^2\varphi^2 + b^2}} - \sin^{-1}\sqrt{1 + \frac{2ab\varphi}{a^2\varphi^2 + b^2}}\right\} \quad \text{where } h = \frac{2ab\varphi}{a^2\varphi^2 + b^2}$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\sqrt{1 + h} - \sin^{-1}\sqrt{1 + h}\right\}$$

$$= \frac{1}{\sqrt{a}}\left\{\sin^{-1}\left(1 + \frac{h}{2} - \frac{h^2}{8} + \frac{h^3}{16}\right) - \sin^{-1}\left(1 + \frac{h}{2} - \frac{h^2}{8} + \frac{h^3}{16}\right)\right\} \quad \text{rejecting } 3rd \text{ \& higher powers}$$

$$= \frac{1}{\sqrt{a}}\left[\left(\frac{\pi}{2} + \Delta\right) - \left(\frac{\pi}{2} - \Delta\right)\right]$$

$$= \frac{1}{\sqrt{a}}\,\pi$$

$$\therefore \quad T = 2\pi\sqrt{\frac{MK^2l}{E}} \quad \text{as before to the 1st approximation.}$$

Record supplied by Mr Wirt of a test made by him of the insulating power of asbestos shielding. 27th November. 1888.

A brass tube 6·4 cms ext. diam. and 47·5 cms long was covered centrally by a sheet of asbestos paper 21·5 cms wide, 28·5 cms long and 0·175 cms thick. This split outer asbestos tube was then tightly overwound with bare copper wire laid up close. The area of asbestos thus interposed under metallic pressure was 21·5 × 28·5 = 613 sq. cms. The res. between the wire and brass tube was at first 47000 but lying over the steampipes for about an hour this rose to over 10.
When so supported over two bunsen burners and in their flames for 15 mins, the defl. by trigs above 12 was 150 and below inf. 10. It is certain that the part of the outside of sample in the flame was up to dull red temperature.

On a calculation of the time of oscillations of a pendulum

Let m be the mass of the small bob
l . . length of the thin string
φ . . semiarc of oscillation
θ . . angle of deviation at any moment
s . . arc
h . . elevation of the c.g. of m at φ
g . . acceleration of gravitation

Then $\frac{d^2\theta}{dt^2} + \frac{g}{l}\sin\theta = 0$ and when θ is small this is practically the same as $\frac{d^2\theta}{dt^2} + \frac{g\theta}{l} = 0$

$$\therefore \quad 2\frac{d\theta}{dt}\frac{d^2\theta}{dt^2} = -\frac{2\theta}{dt}\frac{g\theta}{l}$$

$$\therefore \quad 2\left(\frac{d\theta}{dt}\right)^2 = -\frac{g}{l}\theta^2 + c$$

c is defined by the condition that when $\theta = 0$, $\frac{m}{2}\left(\frac{d\theta}{dt}\right)^2 = mgh = mg\frac{\varphi^2}{l} = \frac{mg}{l}l^2\varphi^2$

$$\therefore \quad \left(\frac{d\theta}{dt}\right)^2 \text{ then } = \frac{g}{l}\varphi^2$$

$$\therefore \text{ generally } \left(\frac{d\theta}{dt}\right)^2 = \frac{g}{l}(\varphi^2 - \theta^2)$$

$$\therefore \quad \frac{d\theta}{dt} = \sqrt{\frac{g}{l}(\varphi^2 - \theta^2)}$$

But the time occupied by a semioscillation is

$$\int_{-\varphi}^{+\varphi}\frac{dt}{d\theta} = \int_{-\varphi}^{+\varphi}\frac{dt}{d\theta}\,d\theta = \int_{-\varphi}^{+\varphi}\sqrt{\frac{l}{g}}\sqrt{\frac{1}{\varphi^2 - \theta^2}}\,d\theta$$

$$= \sqrt{\frac{l}{g}}\int_{-\varphi}^{+\varphi}\frac{d\theta}{\sqrt{\varphi^2 - \theta^2}} = \sqrt{\frac{l}{g}}\,\sin^{-1}\frac{\theta}{\varphi}\Big]_{-\varphi}^{+\varphi} = \sqrt{\frac{l}{g}}(\sin^{-1}1 + \sin^{-1}1)$$

$$= \sqrt{\frac{l}{g}}\,2\frac{\pi}{2} = \pi\sqrt{\frac{l}{g}} \quad \text{so that a complete period} = 2\pi\sqrt{\frac{l}{g}}$$

For a simple watch spring the equation of motion is approximately

$$\frac{d^2\theta}{dt^2} = -\frac{E\theta}{MK^2l}\theta \quad \text{where } M \text{ is the mass of the balance wheel + spring}$$

K . . radius of gyration
l . . length of the spring
E . . coefficient of rigidity

$$\therefore \text{ as before } T = 2\pi\sqrt{\frac{MK^2l}{E}}$$

With an opposed electrodynamic force of $2a\frac{d\theta}{dt}$ resisting the motion the equation becomes, neglecting friction.

$$\frac{d^2\theta}{dt^2} + 2a\frac{d\theta}{dt} + b\theta = 0 \quad \text{where } b = E/MK^2l \qquad (1)$$

Assuming that $\theta = ce^{mt}$ we have the auxiliary equation

$$m^2 + 2am + b = 0 \quad \text{The solution of which gives}$$

$$m = -\frac{a}{2} \pm \frac{\sqrt{a^2-4b}}{2} \qquad (2)$$

Since b is about 1000 and a is small relatively to it, these roots are imaginary and are $= -\alpha \pm \beta(I-I)$ where $\alpha = \frac{a}{2}$ and $\beta = \sqrt{b-a^2}$ and the general solution of the differential equation is

$$\theta = Ae^{-\alpha t}\cos\beta t + Be^{-\alpha t}\sin\beta t \qquad (3)$$

When $\theta = +\varphi$ let $t = 0$ and $\frac{d\theta}{dt} = 0$ (4)

also when $\theta = 0$ - $t = \frac{\tau}{2}$ - $\frac{d\theta}{dt} =$ a maximum (5)

- $\theta = -\varphi$ - $t = \tau$ - $\frac{d\theta}{dt} = 0$. (6)

Then since $\frac{d\theta}{dt} = -Aae^{-\alpha t}\cos\beta t - A\beta e^{-\alpha t}\sin\beta t - Bae^{-\alpha t}\sin\beta t + B\beta e^{-\alpha t}\cos\beta t$ (7)

Then by (4) $\therefore 0 = -Aa + B\beta$ (8)

and by (3) $\varphi = A$ φ being the limiting angle. (9)

$\therefore B = \frac{a}{\beta}\varphi$ (10)

and the solution is $\theta = \varphi e^{-\alpha t}\cos\beta t + \frac{a\varphi}{\beta}e^{-\alpha t}\sin\beta t.$ (11)

Since θ at $t = 0$ $= -\theta$ at $t = \tau$

we have $\varphi = -\varphi\left\{e^{+\alpha\tau}\cos\beta\tau \mp \frac{a}{\beta}e^{+\alpha\tau}\sin\beta\tau\right\}$

$\therefore 1 = -e^{+\alpha\tau}\cos\beta\tau + \frac{a}{\beta}e^{+\alpha\tau}\sin\beta\tau$

$\therefore \cos\beta\tau = \frac{-1}{e^{+\alpha\tau}} + \frac{a}{\beta}\sin\beta\tau$

$= -e^{-\alpha\tau} + \frac{a}{\beta}\sin\beta\tau$

when a vanishes this $= -1$

and $\beta\tau = \cos^{-1}(-1) = \pi$

$\therefore \tau = \frac{\pi}{\sqrt{b}}$

but when a is not zero $\tau = \frac{1}{\beta}\cos^{-1}\left(-e^{-\alpha\tau} \mp \frac{a}{\beta}\sin\beta\tau\right)$

a result which is meaningless for $\mp$ values of a.

The quantity $\frac{a}{\beta}\sin\beta\tau$ is very small and neglecting it

$$\tau = \frac{1}{\beta}\cos^{-1}\left(-e^{-\alpha\tau}\right)$$

Multipolar Dynamo Test.

December 3rd Monday.

10.50 Commenced running multipolar direct from #1 engines no other belt or shafting being driven.
The field magnet coils in 4 sets of 4 coils each.

10.57 Speed about 820 revs. per min. Volts 160 Amperes in field 4.2

Time	Hours at stay-bolts	Length No. of coils	Mhos. reading	Field Current	Current in Coils	Volts at M.T.	Speed	Amperes	Deflection on 35 mm	Amperes by Cond.	
10.57	0.00	2	0.66	4.2	10.5	160	820	.95	25	196	
11.00	.03	4	1.32	40.5	10.1	155		220	48	205	
.03	.04	6	1.98	37	9.2	149		270	69	298	
.05	.06	8	2.64	36	9.0	143		370	80	378	
.07	.10	10	3.3	35	8.8	139		425	92	459	
.09	.12	12	4.0	34.5	8.6	135		—	102	540	
.11	.14	14	4.66	32	8.0	129		—	109	600	
.12	.15	16	5.33	30.2	7.6	127		—	115	677	
.14	Stopped for adjustment. Highest temp. reached on armature 135°F. Remove bolt										
12.00	Started running again having displaced mains.										
.01	0.01	2	0.66	39	9.75	160	820	—	22	107	
.02	0.02	6	2.0	37	9.25	149		—	48	298	
.03	0.03	10	3.3	36.5	9.1	138		—	86	445	
.04	0.04	14	4.66	32.2	8.1	136.5		—	110	636	
.06	0.06	18	6.0	28.7	7.2	115		—	130	690	
.10	0.10	22	7.3	26.2	8.7	107		—	148	781	
13.00	1.00	22	7.3	25	6.25	105		—	120	747	
	Stopped on account of hot bearing. Highest temp. reached 205°F.										
15.30	0.00	2	0.66	41	10.03	160	820	.95	28	107	
.35	0.05	6	1.98	37	9.25	150	—	280	50	300	
.40	0.10	10	3.3	33	8.25	138		430 = 320	78	460	
.43	0.13	18	6.0	29	7.00	120		300 = 587	115	720	
.45	0.15	20	6.7	27	6.75	114		360 = 673	114	760	
.50	0.20	22	7.3	25	6.25	109		370 = 692	125	791	
.55	0.25	26	8.7	24	6.0	102		385 = 720	109	720	
16.00	0.30	19	6.3	25	6.25	101		340 = 636	95	636	
.12	0.42	19	6.3	23.5	5.9	104		335 = 627	83	636	
.40	0.10	19	6.3	24	6.0	100		335 = 627	85	620	
17.30	Stopped to alter arrangement of magnet coils + on account of steam. Highest temp. reached 221°F.										
	Arranged the coils in 5 sets of 3 with one extra one in whose circuit an ammeter and resistance box were also inserted.										
19.40	0.00	20	6.7	62	10.2	130		375 = 750	109	867	
20.10	.30	20	6.7	55	9.2	123		370 = 740	"	820	
21.10	1.30	Stopped to fit brushes. Highest temp. at 21.35 = 221°F.									
22.30	.00	Started again having fitted brushes									
22.30	.00	20	6.7	53	8.8	115		360 = 720	"	770	
23.30	1.00	20	6.7	48	8.0	110		350 = 700		730	
24.30	2.00	20	6.7	47	7.8	110	725	345 = 690		730	
25.00	2.30	20	6.7	44	7.3	102	720	325 = 650		680	steam low
2.00	3.30	20	6.7	45	7.5	103	705	325 = 650		655	" " 660
3.00	4.30	20	6.7	45	7.5	104	730	325 = 650		693	" "
	Stopped to fit brushes. Highest temp 250°F.										
4.30	0.00	20	6.7	57	9.5	120	790	375 = 750		800	
5.30	1.00	20	6.7	49	8.2	113		360 = 720		763	
6.00	1.30	20	6.7	48	8.0	112	700	360 = 720		750	
6.30	2.00	20	6.7	47	7.8	112		350 = 700		750	
7.00	2.00	20	6.7	47	7.8	112		350 = 700		750	Stopped

Water Tank 76°F.

Physiological Experiments.

December 4th Wednesday.

Cardew voltmeter Readings.

°	23°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°	110° Resumed 100°	110°
	43	49.6 / 1.0	54.4 / 0.96	62.0 / 1.52	67.8 / 1.16	72.8 / 1.0	79.0 / 1.24	85.2 / 1.24	89.2 / 0.8	92.9 / 0.74	97.4 / 0.92	102.0 / 0.92	106.8 / 0.96	112 / 1.04	Catch lost 122	132

Res: of Cardew at 22°C 681 ω

Additional Platinum wire Resistance I 670 ω, I + II 2061 ω, I + II + III 4205 ω

Res of converter for occasion: Primary 0.09, Secondary 10.75

Took two g.p. covered wire into Ore-Milling House as mains

" " cotton " " " " " Field cot leads.

The Board appointed by the Medico-Legal Society arrived about 1¾ o'clock. Dr Dorcum, Professor Dourmer, Mr Gheny, Dr Peterson, Dr Ingram and Mr Brown being among the number. Two electrodes of metal covered with sponge were supplied by Dr Peterson. Connecting wire were soldered to them.

The animals provided for the occasion were a horse (photographed) weighing and 2 calves weighing respectively 124½ and 145 lbs.

Tried the first calf with the converter sent from N.Y., the coarse wire circuit being on the machine and the fine wire on the animal. The P.D. at the moment of making contact was indicated by 90° with 10 lamps of 230 ω each and the whole bound of 4200 in cct. 6500 ω in cct $= 112 - 11.2 = 100.8 \times \frac{6500 + 680}{680} = 101 \times \frac{7180}{680} = 1070$ say 1100.

Immediately after breaking the circuit the P.D. was 84° = 106 − 10.6 = 96 × 10.6 = 1015 say 1000.

During the contact which lasted for 30 seconds the deflection fell to about 25 which would mean perhaps 10 volts × 10.6 = say 100. $\frac{15 \times 100}{16 \cdot 25}$ $\frac{15 \times 100}{16 \cdot 25 \cdot 25}$

The animal fell unjigged.

Finding that the converter failed to sustain the E.M.F., used the current from the machine direct.

The voltage before making contact was 110° = 132 − 13 = 119 × 7 = 833

During contact the mean deflection was 100° = 122 − 12 = 110 × 7 = 770

The contact lasted 8 seconds. Breathing ceased in 1½ mins.

The resistance between the electrodes before death was 3200 ω approx.

Second calf weighing 145 lbs; Res between electrodes 1300 ω. 16.36 16.36.25

Direct action of the machine as before alternating 200 times per sec.

The voltages were 110° before contact = 833 and 98° during contact = 750.

Contact lasted for 5 seconds.

Breathing ceased in 1½ mins.

Horse, thrown, and its four feet tied together.

Tried converter to attain high momentary voltage but not successful. Obtained as high voltage that cardew gave way and so there unable to measure voltage used lamps.

With 10 lamps from converter = about 1000 volts gave momentary current the voltage falling immediately. Horse unjigged.

Resorted to machine current with 7 lamps not quite up to brilliancy say 600 volts. Contact made for 15 seconds. Horse subsequently struggles but not fatally injured. Renewed contact at full brilliancy of 7 lamps for 25 seconds. Respiration then very shortly ceased.

The contact on the calves were made on the forehead and by the side of the spinal column just behind the scapula on the fore leg. The electrodes were soaked in water solution and the hair was clipped. With the second calf cotton wads well soaked was added as a padding. In the case of the horse the electrodes consisted of bandages of soaked wads parcelled with tin wire on the fore leg above the knee.

Resistance of Zinc Sulphate solution under pressure contd —

December 5th Thursday

Since the diminution which has been visible in the resistance of zinc sulphate solution under pressure might be possibly due to expansion of the glass tube in air, the shape of the pressure-tube was altered so that the greater part of it was immersed in the pressure-chamber where it could receive equal pressures on the inside and outside.

Referring to the figure from A L B the wire was sealed a distance of about 1 cm.

Int Dia = 0.25 cm
Ext - 1.50
Wall thickness 0.53

B b C - wire with its amalgamated zinc surface passed into the liquid for about 2 cms, and the ends of the collar at C was about 0.3 cm from the end of the wire.

C b D the tube passed for 10.9 cms inside the collar.

D b E the tube continued for 15.5 cms.

E b F is 2 cms.

So that when an amalgamated zinc covered platinum wire was inserted at F and projected to E the length of the liquid column between the electrodes would be about 26.5 cms of which more than half was under both outside external as well as internal pressure. The following results were obtained with solution the same as that last used and recorded on page 44.

No of obs	Time	Bridge no.	Observed Pressure	Magnifying power by 1 cm.	Observed Res.	Calc for Temp	Δr	Δp	Δr/Δp	Coef of pressure Δr/Δp	Ratio
1	17.50		1	1.01	9630	9640					
2	.51		50	50.5	9560	9570	-70	+49	1.43		
3	.52		1	1.01	9640	9650	+80	-49	1.63	1.53	$\frac{R_1}{R_0} = 1.008$
4	.53		100	101.	9480	9490	-160	+99	1.62		
5	.56		1	1.01	9670	9680	+170	-99	1.72	1.67	$\frac{R_2}{R_0} = 1.019$
6	.57		150	152.5	9460	9470	-210	+149	1.41		
7	.59		1	1.01	9700	9710	+240	-149	1.61	1.51	$\frac{R_3}{R_0} = 1.025$
8	18.00		200	202.	8700	8710	-1000	+199	5.0		$\frac{R_4}{R_0} = 1.042$
9	.02		1	1.01	9070	9080	+370	-199	1.86		
10	.03		250	252.5	8600	8610	-470	+249	1.88	1.86	$\frac{R_5}{R_0}$
11	.04		1	1.01	9060	9070	+460	-249	1.84		
12	.05		300	303	8380	8390	-680	+299	2.27		

Bridge no. 6 = 0.6 mm
Bridge no. 4 = 1.2 mm
Temp of the tube T = 25.4° C.
Tube broke at 300

The following observations of variation of density with temperature were taken with heated water solution.

1.031	@ 78° C		
1.034	@ 70°	0.005 for 10°	0.0005 per °C
1.040	@ 60°		
1.045	@ 50°	0.005 - -	-
1.048	@ 45°		
1.050	@ 40°	0.005 - -	-
1.054	@ 27°		
1.056	@ 22°	0.005 - 15°	0.00033 - [illegible]

Copy of Mr H. P. Brown's notes of the experiments on the 5th Dec.

Calf No. 1. weighing 124½ lbs. was found to have an electrical resistance of 3200 ohms. A sponge-covered disc electrode 2" in diameter was applied to the forehead between the eyes, the hair being first clipped. The second electrode was made of wire netting 4" long and 2" wide covered with sponge and applied to the left of the spine back of shoulders. The sponges were saturated with a solution of Zn SO4 having a density of 1.054 at 60°F

A Siemens alternating current dynamo was used, its fields being changed from a standard Edison dynamo, and its EMF regulated by variable res. in the field circuit.

In the first experiment the main current was passed through the low resistance coil of a large converter made by an electric light co. and the calf was placed in the circuit of the high resistance coil for 30 sec. Before closing the circuit at 3.50 pm, on the subject the Cardew voltmeter showed 1100 volts in the secondary but as soon as closed the potential at once fell to 100 volts and remained stationary. The animal dropped but was uninjured as it rose to its feet 9 min. later.

The converter was then disconnected and the main current at 770 volts was applied for 8 seconds. Death was instantaneous. The animal was at once dissected by Drs Bleyer and Ingram. In the brain the vessels were found filled with blood but there were no hemorrhages. The brain remained very warm even after being exposed for few minutes to the air and immersed in cold water. The heart and lungs were found to be perfectly normal. The hair on the forehead projected beyond the sponges and touched the metal plate of the electrode and was scorched, but the skin was uninjured.

The second calf weighed 145 lbs and had an electrical resistance of 1300 ω between the electrodes which were placed as before, the metal of the disks being further protected by wrapping the edge with cotton waste. At 4.26 pm the alternating current at 750 volts was applied for five seconds. Death was instantaneous and the heart action ceased at once but reflex movements upon excitation were observed for 1½ mins.

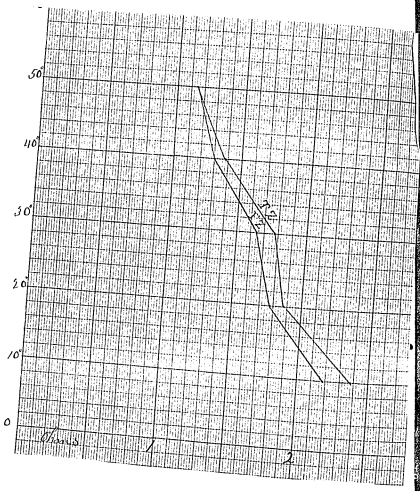
The calves were purchased from a butcher and were in good condition. The meat was pronounced fit for food, the fact being certified by him in writing.

A horse weighing 1230 lbs with halter was the next subject. His hip was dislocated but otherwise he was in good condition. Connection was made by wrapping cotton waste saturated in water round each fore leg and holding in place with bare copper wire. It was suggested by the physicians present that with this connection the current would pass through the muscles of the chest and not reach the spine or heart. This proved to be the case. The resistance was found to be

11,000 ohms. It was attempted to pass an alternating current of 1200 volts through the animal for a fraction of a second by closing the circuit with the rapid blow of a hammer on a metal plate but in preparing for the experiment the Cardew voltmeter was disabled. A file of lamps was then substituted and the EMF calculated. The current from the dynamo was passed through the converter above mentioned but with unsatisfactory results in obtaining the desired EMF in the secondary circuit. A ring converter was then tried and abandoned. A smaller ring converter was then substituted and the field circuit resistance adjusted until the a series of 18 lamps of the Edison type were brought up to redness in the secondary circuit. The current was then applied by a single tap from the hammer at 5.20pm but the animal was uninjured. The converter which was deemed of insufficient capacity for the purpose was abandoned and the dynamo circuit used. A series of 7 lamps was connected to the primary wire and brought up to redness. At 5.25pm contact with the horse was made for 5 seconds but the animal was uninjured. At 5.27 the same current was applied for 15 seconds with no apparent injury. The file of 7 lamps was then brought up to bright incandescence and the current was applied for 25 seconds at 5.28pm. during which time the water in the cotton waste steamed. The result was fatal.

These experiments proved the head and spinal column to be the best points of application of the current for the purpose and disposed of the suggestion to need wrettets as electrodes.

Those present were Eldridge T Gerry. Professors R. Ogden Doremus, Chas. A. Doremus, Dr Frederick Peterson. Dr Frank A. Ingram. Dr J Mount Bleyer. M. Bourgonon, Mr John Murray Mitchell Mr Galvin, and Mr Thos A Edison Mr A. E. Kennelly, and Harold P. Brown.



6 .25 light bottles were made up as follows

LVIII New cast zinc electrolytically pure not amalgamated but cleaned with sandpaper in heated (boiled) $Zn SO_4$ c.c. metre solution.

LIX New cast zinc 5% alloy, not amalgamated but cleaned with sand paper in boiled $Zn SO_4$ c.c. metre solution.

LX New cast zinc electrolytically pure amalgamated hot and in boiled $Zn SO_4$ c.c. metre solution

LXI New cast zinc 5% alloy) amalgamated hot and in boiled $Zn SO_4$ c.c. metre solution.

{LXIII, LXIV} New cast zinc 5% alloy) amalgamated hot and in boiled $Zn SO_4$ c.c. metre solution. Varnished on backs and sides.

LXII New cast pure zinc amalgamated hot and in boiled $Zn SO_4$ c.c. metre solution. Varnished on backs and sides.

The plates were heated by boiling them in water, and then amalgamating them in cool mercury.

The solutions were all cool before immersing the zincs in them.

December 6th Friday.

Took a temperature series on bottles #s LXIII and LXIV. by immersing them in water to the lids, contained in a large copper vessel and maintaining the temperature for a long time to allow uniformity. The current was kept flowing through them.

Bottle	Bridge	Mag. thro bottle	Temp: of bottles	Res: std	Lead	Res of bottle	Av. res. of each bottle Ex	Av. res. of each bottle Ex	
LXII	1000/0	10	19°	5.60	0.25	5.35	2.68	2.68	
LXIV	21°C		50°	2.55		2.30	1.15	1.15	
in series			40°	2.85 f2 3.00 f2		2.60 2.75	1.38	1.30	
			30°	3.79 f2 3.54 f2		3.55 3.39	1.78	1.65	
			21°	4.00 f2 3.80 f2		3.75 3.55	1.88	1.78	
			10°	5.00 f2 4.60 f2		4.75 4.35	2.38	2.18	

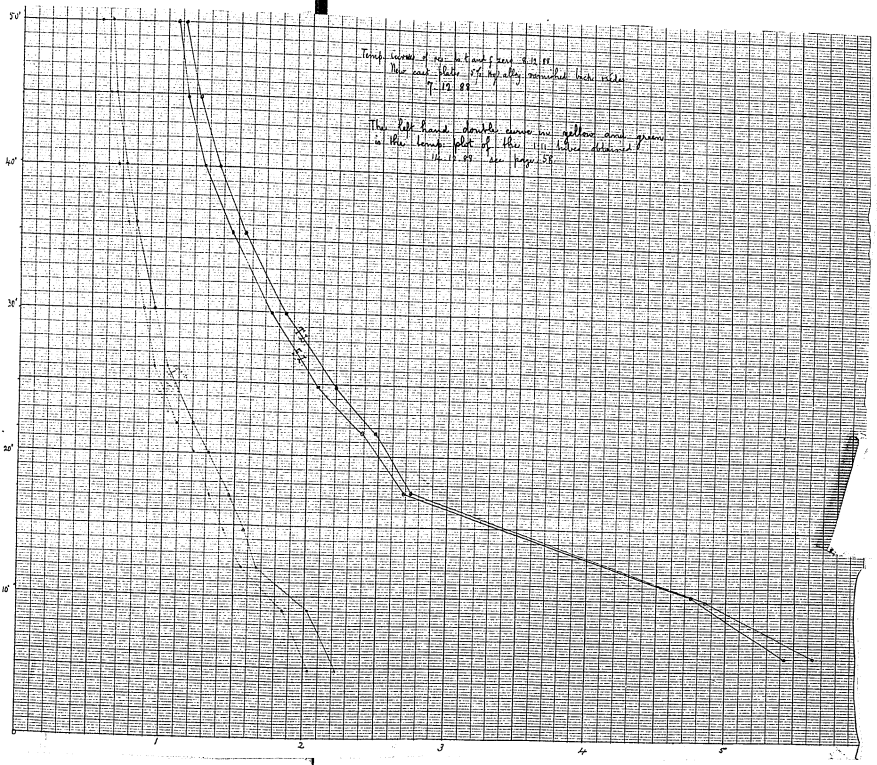
The plot of these observations with temperature as ordinate and resistance as abscissa is shown on the curve sheet opposite.

The irregularity of the curve, particularly at 30°C is presumably due to the non coincidence of the temperature inside the sealed bottle with that outside in the heated liquid.

To overcome this source of error :—

December 7th Saturday.

The plates were taken out of these bottles and immediately amalgamated without heating them. They were then replaced and the lids left off so that the two standard thermometers could be immersed directly in the bottles, joined up in series. They were first placed in icewater till the temp: had fallen to 5°C and then they were allowed to rise in air to the normal, afterwards they were heated to 50°C steadily in water over a burner.


Temp. curves of 10 in tank of sea 6.12.88
The case plate is typically recorded back inside
7.12.88
The left hand double curve in yellow and green is the temp. plot of the 11th tube obtained 11.12.88 see page 58.
50°
40°
30°
20°
10°
1
2
3
4
5

December 7th Saturday) contd:—

The following readings were then obtained, the plot is given opposite

Ref. No.	Bridge	Current thro bottle	Temp. Bridge	Temp. bottle EXP	Temp. bottle CED	mean temp	Res. dect	lead	Amp. bottle	Average Res. L F2.	average Res. L F2	
1	1000/0 Gravity cell	10 mas	25°C	6·0°	6·0°	6·0°	11·50 T 11·10 F	0·25	11·25 10·85	5·63	5·43	
2			10·1°	10·2°	10·25°		9·95 F 9·55 F		9·70 9·30	4·85	4·65	
3			17·2	17·6	17·4		5·7 F 5·4 F		5·65 5·35	2·73	2·68	
4			21·6	21·6	21·6		5·2 F 5·0 F		4·95 4·75	2·48	2·38	
5			25	24·6	24·8		4·60 F 4·40 F		4·40 4·15	2·20	2·08	
6			29·8	29·9	29·9		3·85 F 3·75 F		3·70 3·50	1·85	1·75	
7			35·5	35·0	35·2		3·35 F 3·17 F		3·10 2·92	1·55	1·46	
8			40·2	40·0	40·1		2·95 F 2·79 F		2·73 2·53	1·37	1·27	
9			44·9	44·6	44·8		2·70 F 2·55 F		2·55 2·30	1·23	1·15	
10			50·7	50·2	50·5		2·51 F 2·40 F		2·26 2·15	1·13 ~~2·05~~	1·08	

The res: at 22·9°C of the spools and wire between the copper clips of Bergmann's new special meter with the T.B. 25°C = 1000/0

Repeated this test on the 9th Dec: and both equal (about 17·78ω). above discrepancy probably slight

Left hand 18·662 = 19·38ω Right hand 19·042 = 17·78ω

The following hypothesis is now under consideration by evidence. To account for the improved behaviour of the plates in the meter bottle after amalgamating the plates hot and heating the solution.

Under ordinary conditions as met with in present practice, the zinc plates in the presence of mercury and water forms $Zn(HO)_2$ taking the oxygen either from gas occluded under the amalgamated surface or from dissolved oxygen in the solution and the hydrogen from such traces of acid as may be in solution or from the water the reaction being

$$2Zn + 2(H_2O) + O_2 = 2\{Zn(HO)_2\}$$

When however this salt which is more or less insoluble is not formed owing to the absence of the necessary oxygen by driving off the dissolved solution gas, and the occluded gases in the metal then the following reaction slowly goes on between the zinc and the $ZnSO_4$ in the presence of water

$$Zn + 2H_2O + ZnSO_4 = ZnSO_4 \cdot Zn(OH)_2 + H_2$$

The basic sulphate here formed should have a slightly alkaline reaction. It is said to be soluble in small quantities. Hydrogen would be evolved.

It remains to be seen whether the gas that forms on the plate surface is really hydrogen, and whether the same reaction can be obtained with pure zinc without the presence of mercury.

Constant of no 2 (smaller) A+S Engine in Dynamo room. Rect 1½ (13×12)

Front constant $\frac{(132.73 - 2.23) \times 1}{33,000} = 0.0039$

Back constant $\frac{132.73 \times 1}{33,000} = 0.004402$

Meter Experiment contd.

Sunday 9th December.

No. of plate	No. of plate	Meter	Mean Temp. of meter	Average Load	Weight susp.	Sum of weights	Joint stat weights	Weight susp. 28.11.88	Loss	Gain	
I	1	Exp. Std.	18°	3.8 amp.	88.5230	176.3933	176.3950	86.9887	0.4657		
	2				87.8703			87.3990		0.4713	
II	3	Std. #1	21°		88.5276	179.1781	179.1810	89.0018	0.4742		
	4				90.6505			90.1742		0.4763	
III	5	Std. #2	21°		88.8066	173.6221	173.6260	89.2789	0.4753		
	6				84.8155			84.3411		0.4774	
1	1	Gold meter	4°		79.850			79.310	0.460		
1a	1a				75.998			76.400	0.402		
2	2	Warm meter	25.6°		82.146			82.625	0.429		
2a	2a				79.556			80.010	0.456		
3	3	None			82.100			82.1295		0.030	
3a	3a				77.828			77.815		0.013	

			Date of preparation	Days intervene	Loss corrected for error of meter	Gain add for error of meter	Mean Std Loss.	Ratio of stat. to Std loss.	Error.	Gain by oxidation.
I	1	Exp. Std.	28.11.88	11	0.4739	0.4707		1.0040	+0.4%	
	2					0.4795				0.0056
II	3	Std. #1	"	11	0.4768		0.4756	0.9974	−0.26%	
	4					0.4789		1.0012	+0.12%	0.0021
III	5	Std. #2	"	11	0.4762					
	6					0.4784				0.0022
1	1	Gold meter	4°	27.11.88	12	0.460		0.967	9.4%	
1a	1a					0.402		0.845		
2	2	Warm meter	25.6°	"	12	0.429		0.902	7.0%	
2a	2a					0.456		0.959		
3	3	None		"	13					0.030
3a	3a									0.013

Monday 10th December.

Made up 3 bottles as follow

XV } Zincs of Benmanix ordinary pattern twice in use, amalgamated
XVI } when hot after boiling water with mercury itself new
XVII } boiling temp. of water. solution 1.0514 heated separately to boiling.

No. of bottle	No. of plate	Meter	Mean temp.	Av. load	Weight susp.	Sum of pairs	Joint stat weights (between)				
XV	1	Std. #2		10 amp	87.1247	173.8620	173.8646				
	2				86.7373						
XVI	3	Gold special			90.9108	175.4392	176.4335				
	4				85.5284						
XVII	5	Gold special			86.0237	172.0794	172.0787				
	6				86.0557						

These bottles were intended for a companion of the special meter with the standard #2. The special meter was set in the refrigerator in place of commercial 25 meter #1. They commenced work at 9.0 am on the 11th at 10 amperes of current.

Meter Experiments contd —

December 10th Monday

Made up two narrow bottles out of glass tube cut and closed so as to just hold the connected plates. The height of the bottles so formed was 13.4 on the inside and the diameter 3.5 They were corked and labelled nos. XLVIII and XLIX. The plates were amalgamated hot and the liquid was boiled.

December 11th Tuesday.

Meter experiments contd.

Took down bottles LXIII and LXIV and reamalgamated the plates hot Boiled some 1.111 solution and inserted the plates after cooling.

Refilled them Nos LXX and LXXI.

The resistance of these on the 11th Dec. with 1 ampere @ 21.2°C = {2.92 / 2.94} + {3.19 / 3.22} respectively.

December 12th Wednesday.

Different trials made of solutions &c.

The following decisions were come to in conference with Mr Witt on the details of the proposed new Edison meter subject to the approval of the Standardizing Bureau

1st That the resistances of the bottles and the data connected with them should be expressed in legal unit.

2nd That the shunt resistances should be doubled.

3rd That the resistance of the bottle should be approximately 2 ω @ 60°F or 15.5°C

4th That the plates should be varnished on their backs and rims

5th That the resistance should be so arranged in the bottle circuit as not only to compensate for temperature but also to give 1 milliampere for each ampere hour of current.

6th That the bottles should be reduced in dimensions so as to just fit the plates.

7th That the foot at the base connection should be reduced to about ¼".

8th That the density of solution should be increased to about 1.11 or to such a value that the res. of the bottle should be 2.0 ω @ 15.5°C.

9th That no larger plates should be employed than the 25th plate and that all alterations for larger meters would take place with the aid of the shunt.

December. 13th Thursday.

A test was made of a leaden plate battery forming a primary cell with chemical excitants but having all the appearance of a secondary cell. The plates are 9 in number on each grid 30 high 15.5 broad 0.3 thick and the grids slide into each other vertically in such a manner that the interspace between the opposite faces is 0.25 cm. The total area on each plate is about 450 × 2 = 900 and on each grid effectively about 7200

These grids were immersed overnight in separate solutions and then coupled in one of these solutions for work.

An E.M.F. of about 2 volts and a capacity of 25 Ampère hours was claimed for them by their inventor Mr Jenkin The cell was set to work upon a measured 0.5 of platinoid.

December 13th Thursday. Reading battery test.

Hours	Time	Hours at work	EMF	P.D.	C.	I.R.	Watts	Mean EMF	Joules.	Joules up to present	Ave. Watts for hour
1	9.00	0.00	1.940	1.924	3.848	0.0042					
2	9.15	.15	1.924	1.910	3.820	0.0037	7.407	1.932	6670	6670	
3	9.30	.30	1.908	1.892	3.784	0.0042	7.285	1.916	6560	13230	
4	10.00	1.00	1.884	1.864	3.728	0.0053	7.121	1.896	12820	26050	
5	10.30	1.30	1.890	1.866	3.732	0.0064	7.038	1.887	12670	38720	
6	11.00	2.00	1.768	1.730	3.460	0.0110	6.577	1.829	12040	50760	
7	11.30	2.30	1.405	1.274	2.548	0.052	4.770	1.588	7590	58350	
8	12.00	3.00	1.804	0.982	1.886	0.100	2.709	1.245	4886	63230	
9	13.00	4.00	0.328	0.222	0.444	0.240	0.792	0.705	2850	66080	2.6
									66080		

3.7 amperes may be said to have been delivered for 2 hours and the total capacity cannot exceed 10-ampere hours.
A curve sheet was made out and preserved.

Tested the Transformer armature as follows:—
Resistance of bare wire ring between opposite points 0.17 ω
" " Fine " " " " 4.69 ω
" between the circuits = Practically infinite.

To ascertain whether the resistance of platinoid was liable to sensible variation when heated by current for a long time, measured a strip as follows—
3 Daniells gravitis working thro' 0.1 Legal-Ohm + the 0.1 strip whose ends were soldered into two st meter clips

No. of obs	Deflection no strip	Deflection on strip	Diff	Mean Ratio	Legal Ohm @ 22.5°	Mean Res. of strip	v	v^2	$0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$	Res. of strip @ 22.5°	
1	626.5	624.9	1.6	0.997444	0.10011	0.09984	-3×10^{-5}	9×10^{-10}	0.1508	0.09998	
2	628.0	626.5	1.5	0.99761		0.09987	-1×10^{-5}	1	$\times 8.9\times10^{-5}$	± 0.00009	
3	627.7	626.7	1.0	0.998841		0.09995	$+7\times10^{-5}$	49	$=0.1342$		
4	629.5	628.2	1.3	0.99793		0.09990	$+2\times10^{-5}$	4	$\times10^{-5}$		
5	630.7	629.0	1.7	0.99730		0.09984	-4×10^{-5}	16			
	22.7	25.3						$\Sigma v^2 = 79\times10^{-10}$			
Mean	628.5	627.1	1.4	0.99777		0.09989					

This strip was put in cct: with the carpenter's shop motor.

Measured the resistance of two pairs of 25 lt plates as follows:—
Two 25 lt bottles were used
A had 1.054 solution
B " 1.110 "
Two 25 lt tubs were used 3.7 cms drain
C had 1.054 solution 12.4 " deep
D " 1.110 "
Couple 1 was formed of plain freshly amalgamated plates
" 2 " " " cast 5% plate " and varnished on the backs sides with 2 coats of Japan.
To lower the resistance a current of about ½ ampere was sent through these couples in solution for about an hour beforehand.

Couple #1

Obs.	Res. in A 1.054 bottle	Res. in B 1.111 bottle	Res. in C. 1.15 tube	Res. in D. 1.111 tube	Change
1				{1.02 / 0.97}	
2		{0.96 / 0.94}			{−0.06 / −0.03}
3	{2.85 / 2.30}			{1.89 / 1.36}	
4			{2.42 / 2.37}	{+0.47 / +0.01}	
5		{1.03 / 1.01}		{−1.39 / −1.36}	
6				{1.20 / 1.18}	{+0.17 / +0.17}
7		{1.20 / 1.19}			{−0.0 / +0.01}
8				{1.32 / 1.20}	{+0.12 / +0.11}
9					
10					

Couple #2

Obs	Res. in A 1.054 bottle	Res. in B. 1.111 bottle	Res. in C. 1.15 tube	Res. in D. 1.111 tube	Change
1				{1.09 / 1.06}	
2		{1.19 / 1.15}			{+0.11 / +0.09}
3	{1.99 / 1.95}				{+0.80 / +0.80}
4			{1.93 / 1.85}		{−0.06 / −0.10}
5		{1.01 / 0.98}			{−0.92 / −0.87}
6				{1.02 / 0.99}	{+0.01 / +0.01}
7		{1.02 / 0.99}			{0.00 / 0.00}
8				{1.02 / 0.99}	{0.00 / 0.00}
9			{2.05 / 1.93}		{+1.03 / 0.94}
10	{2.05 / 1.93}				{0.00 / 0.00}

The temp: of the solutions was about 18°.6 c.

The effect therefore of changing a plain couple from bottle to tube was

for 1.054 solution . {0.07 / 0.03}

" 1.111 " {0.07 / 0.03}

with a varnished couple

for 1.054 solution 0.

" 1.111 " 0.

The upper value in the bracket is for t.z the lower for f.z.

The res: of no 1. in 1.054 tube was {2.42 / 2.37} in 1.11 tube {1.18 / 1.15}

" " " " 2 " 1.054 " " {1.89 / 1.59} " 1.11 tube {1.40 / 1.03}

The res: of the tube seems to fall therefore about 50%.

Observations by Mr Watt upon polarization.

The current was kept steadily on one bottle for the times indicated and readings taken to true and false zero.

No. of Obs	Time	Current on for	R. to T.Z.	R. to F.Z.	Current this bottle	Diff	Temp bottle	ε volt	ε mean
1	9·30	0·0	–	–	1 mamp		25°		
2	·50	0·20	1·18	1·60	–	0·38	23·8°	0·0082	0·00032
3	11·10	0·40	1·20	1·75	–	0·55	23·5°	0·00055	0·00055
4	·15	0·05	1·27	1·37	5	0·16	23·5°	0·0008	0·00016
5	·20	0·05	1·22	1·34	10	0·12	23·5°	0·0012	0·00012
6	·35	0·15	1·33	1·43	15	0·10	23·2°	0·0023	0·00015
7	·40	0·10	1·42	1·53	20	0·11	23°	0·0022	0·00011
8	·50	0·20	1·47	1·60	20	0·13	23·4°	0·0026	0·00013
9	·55	0·03	1·48	1·63	15	0·15	–	0·0023	0·00015
10	·56	0·03	1·49	1·67	10	0·18	–	0·0018	0·00018
11	12·00	0·04	1·49	1·76	·5	0·27	–	0·0014	0·00028

Calculation of the resistance to be put in the bottle circuit of a 25 lt. new Edison meter including the bottle itself.

The Legal ampère liberates 0.00001086 grammes of H. per sec.
Taking the atomic weight of zinc in Watts dictionary 64.90 the corresponding mass of metal disengaged = 0.00033370
Taking the figure in Anthony & Brackett's Physics 65.88 we have
0.00033369 — 65.33
Taking Ayrton's number of
0.00033293

Assuming the number 0.00033370 in the absence of more certain information, we have in one hour

$0.000337 \times 3600 = 3.37 \times 10^{-4} \times 3.6 \times 10^{3} = 12.132 \times 10^{-1} = 1.2132$ grammes.

Consequently the circuit that takes 1 milligramme per hour must have a resistance of $\frac{4}{1.2132 \cdot 2}$ so that in circuit with
0.01 ω we should have a bottle + spool of 12.122 ω
0.02 ω . . . . . 24.2644 ω

In such a circuit, a variation due to bottle changes
of 1 ω produce an error of 4.12 %
" 2 ω " " " " 7.63
" 3 ω " " " " 11.0 %
" 4 ω " " " " 14.2 %
" 5 ω " " " " 17.1 %

The discrepancy between Ayrton's value + Watts value is about 0.7 %.

December 14th Friday.

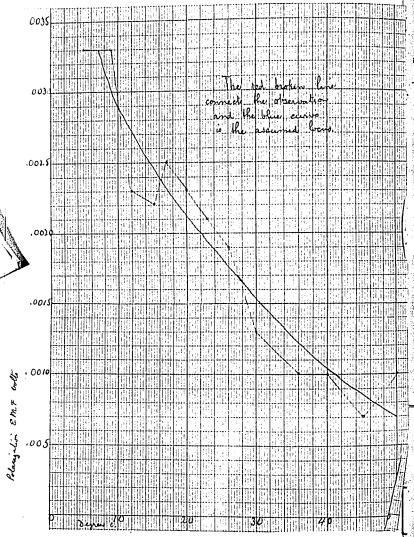
10.0 Metts test stopped, and bottles removed. The bottles in the standard meter was in good condition but those in the special meter placed in the refrigerator were much 'smutted.' No ☐XVII was in fact nearly if not quite bridged over. The resistances of the three bottles just after removal were :-

☐XV in standard meter warm 1.34 to 1.14 f.z.
☐XVI " special " cold 2.44 to 1.49 f.z. av. temp 8°C.
☐XVII " special " " 0.74 " 0.64 f.z.

The plates were then dried and weighed as follows:-

No. of roll	No. of plate	Meter	Mean Temp	Weight wet	Sum	Joint weight	Weight dry at 16° Fah.	Loss	Gain	Discrepancy
☐XV	1	Std. ☐22	22.6	~~87.8349~~	~~173.8629~~	~~173.8629~~	87.1247	~~2.0325~~	~~0.7102~~ ~~0.6255~~	
	2			86.0280			86.7373	~~2.7203~~	~~2.7203~~ ~~0.6017~~	
							173.8646	0.7113		
								0.6017		
☐XVI	3	Special	8°	~~91.4275~~	~~176.2543~~	~~176.2543~~	90.9108	~~1.5581~~	0.5067	
	4			~~84.8268~~			85.5304	0.8836	0.7306	— 3.9 %
							176.4335	0.1780		
☐XVII	5	Special	8°	~~85.3560~~	~~171.5739~~	~~171.5739~~	86.0237	0.6677		Short circuited.
	6			~~86.5619~~			86.0557	~~2.6280~~	0.4613	
							172.0794	0.2027		

The test has been running for 3 days at about 18 hours a day = 54 hours at 10 ampères = 540 ampère hours = 0.6648 transfer.



Meter tests cont:—

Took the resistance of 3 twice bottles Nos [XXII] [XXIII] and [XXIV] made up on the previous day with cast 5% zinc japanned, and 1.111 solution.

at noon. the three in series with 20 m. amps. @ 20.8 °C = $\begin{cases} f_1 .15\ t_2 = 1.38\ \text{cell} \\ f_3 .22\ f_2 \quad 1.27 \end{cases}$

The current was left on till

13. 10 the res. was then - - - - @ 20.2° C = $\begin{cases} f_1 .09\ t_2 = 1.63\ \text{cell} \\ f_4 .44\ f_2 \quad 1.48 \end{cases}$

Tested each separately @follows [XXV] 2.48 t_2, 2.28 f_2.

[XXVI] 1.24 t_2, 1.15 f_2

[XXVII] 1.09 t_2, 1.02 f_2. Total = $\begin{cases} 4.81\ t_2 \\ 4.45\ f_2 \end{cases}$

Selected the two last for a temperature test joined up in series and neglected [XXII] as it seemed unduly high.

Test No.	Time hrs bottle	Res. L.T.2. twice bottle	Res. L.T.1. twice bottle	Res. per bottle t.2.	Res. per bottle f.2.	temp bottle	diff between t.2. & f.2.	e.m.f. of polarization	emf per bottle		
1	20	4.39	4.06	2.20	2.03	4.8°	0.33	0.0066	0.0033		
2	"	4.07	3.74	2.04	1.87	9.0°	0.33	0.0066	0.0033		
3	-	3.34	3.11	1.67	1.56	12.2°	0.23	0.0046	0.0023		
4	-	3.08	2.86	1.54	1.43	14.6°	0.22	0.0044	0.0022		
5	-	2.91	2.66	1.46	1.33	17.°	0.25	0.0050	0.0025		
6	-	2.64	2.41	1.32	1.21	20.°	0.23	0.0046	0.0023		
7	-	2.39	2.18	1.20	1.09	23.°	0.21	0.0042	0.0021		
8	-	2.07	1.88	1.04	0.94	26.°	0.19	0.0038	0.0019		
9	-	1.86	1.73	0.93	0.87	30.°	0.13	0.0026	0.0013		
10	-	1.60	1.50	0.80	0.75	36.5°	0.10	0.0020	0.0010		
11	-	1.46	1.36	0.73	0.68	40.°	0.10	0.0020	0.0010		
12	-	1.31	1.26	0.66	0.62	45.°	0.07	0.0014	0.0007		
13	-	1.23	1.13	0.62	0.57	50.°	0.10	0.0020	0.0010		

Recommenced meter test.

Made up bottles Nos. [XXVI] [XXVII] [XXVIII] with 1.054 solution and the same plates as in the last test reamalgamated hot, but the solution were not heated afresh. Bottle No [XXII] was set in the standard #2, but bottles nos [XXIII] and [XXIV] were placed in the special meter and over the steam pipes. Two other bottles [XXXII] and [XXXIII] were made up with plain amalgamated plates unweighed — one in 1.054 solution, the other in 1.11 solution and both left in a commercial 25 lt meter in the refrigerator.

Bottle No.	Plate No.	Meter	Temp.	Load	Weight weight	Sum.	Weight of pair	Time of start		
	1			10 amp	85.0922	169.0092	169.0102	18 o'clock		
	2				84.0170			11.6.12.88'		
	3				89.7527	176.0637	176.0642			
	4				86.3110					
	5				84.7892	168.1569	168.1578			
	6				83.3677					

To ascertain how far the emitting of plates was affected by the density of the solution, made up four 25 lt. bottles nos. ⊏XXVIII. ⊏XXIX. ⊏XXX. and ⊏XXXI. The peroxides were all prepared cast zincs % of 5% freshly amalgamated after heating. The solutions were not boiled but their densities were as follows:—

No.	⊏XXVIII	1.026	@ 20°C
"	⊏XXIX	1.059	"
"	⊏XXX	1.124	"
"	⊏XXXI	1.200	"

These bottles were joined in series with the gravity battery and ran from at 21 o'clock, the current being 20 milliamperes.

Reading No.	Time	Hours at work	E.M.F.	P.D. across	C.	J.R.	Watts.	Mean EMF	Joules	Joules up to period	Ave Watts for 7 hrs
1	10.45	0.00	1.916	1.904	1.904	0.006	3.648				
2	11.00	0.15	1.899	1.887	1.887	0.006	3.583	1.896	3250	3250	
3	11.15	0.30	1.893	1.873	1.873	0.011	3.525	1.880	3200	6450	
4	11.45	1.00	1.883	1.863	1.863	0.011	3.507	1.868	6340	12790	
5	13.15	2.30	1.754	1.710	1.710	0.025	2.999	1.787	17500	30290	
6	13.45	3.00	1.590	1.499	1.499	0.083	2.393	1.605	4860	35150	
7	14.15	3.30	1.380	1.264	1.264	0.091	1.744	1.383	3670	38820	
8	14.45	4.00	1.154	1.023	1.023	0.128	1.180	1.144	2970	41790	
9	15.15	4.30	1.073	0.914	0.914	0.175	0.980	0.969	2070	43860	
10	15.45	5.00	0.960	0.754	0.754	0.273	0.723	0.884	1620	45480	
11	16.15	5.30	0.879	0.623	0.623	0.410	0.547	0.689	1220	46700	
12	16.45	6.00	0.813	0.520	0.520	0.560	0.422	0.572	860	47560	
13	17.15	6.30	0.743	0.450	0.450	0.650	0.334	0.485	650	48210	
14	17.45	7.00	0.678	0.386	0.386	0.750	0.261	0.418	540	48750	1.93
								Total	48750		

The above table shows the results of a second trial of Jamieson's leaden cell after recharging) during the night. The cell was worked on this occasion through to. The work done was 49000 joules in 7 hours against 66000 in 10 hours on the first occasion.

December 15th (Saturday).

At 8 am there was distinct emitting on the − plate of tube no ⊏XXX 1.124 and very slight emitting on that of ⊏XXVIII 1.026. The other plate tube showed no emitting but gave off gas in bottle. Increased current to 50 milliamperes.

Now increased current to 100 milliamperes.

20 o'clock " " " 200 milliamperes.

The same results followed these currents, 1.026 emitted heavily, 1.124 a good deal and the other not visibly.

December 15th Saturday

Following measurement made of the energy consumed and utilized by the Carpenter's shop Motor which is a No. 4 Edison Dynamo.

No. of Test	Speed	Machine driven	Current	Volts	Watts	H.P.	Machine	HP needed	Sum of amps used outside
1	2000	1	29	112	3248	4.33			
2		12	37		4144	5.52	(a) Circular saw	1.19	
3		123	41		4592	6.12	(b) fig saw	0.60	
4		1234	65		7280	9.98	(a) Planer	3.89	
5		12345	67		7504	10.0	(c) lathe	0.29	
6		123456	95		10640	14.19	(d) boring machine	4.19	
7		1	32		3680	4.77			
8		12	39		4370	5.85	(a) Circular saw	1.08	
9		1	31		3470	4.63			
10		13	38		4240	5.68	(b) fig saw	1.05	
11		1	31.5		3520	4.69			
12		14	48		5380	7.17	(a) planer	2.48	
13		1	31		3470	4.63			
14		15	36.5		4090	5.45	(c) lathe	0.82	
15		1	31		3470	4.63			
16		16	33		3700	4.93	(e) borer	0.20	
17		1	29		3250	4.33			
18		17	41.5		4650	6.20	(f) moulder	1.87	7.50

(a) = shaping (b) = fig saw (c) = lathe (f) = moulding machine
(e) = circular saw (d) = planer (d) = boring machine

The average HP absorbed may therefore be taken as 8 or fully 50 amperes.

December 16th

at noon the emitting experiment was stopped and the bottles examined. The plates were subsequently scraped and replaced without further interference. The emitting was very light and muddy in 1.026 and became harder in each successive density. The quantity was greatest in 1.026 filling almost the entire interspace. It was next most plentiful in 1.124 next in 1.059 and least in 1.201 comparatively little in this last case.

The plates were replaced in the same bottles and raised in them to 100°C. The bottles while still warm were joined up in series and the current of 200 milliamperes started in the opposite direction so that the plate which had been gaining now lost.

The experiment lasted for 40 hours, at the conclusion of which period the current was interrupted.

On examination (18th Dec), the 1.026 had little or comparatively little emitting, the 1.059 was full of smut between the plates the 1.124 formed a gradient like the black triangle between the plates and the 1.20 had a little less. So that the order of quantity in emitting was 1.059 1.124 1.20 and 1.026. Examined the smut microscopically and found it partly composed of fine metallic particles.

Bottle No XI-VII which has been allowed to generate gas under solution in a sealed bottle for 18 days since the 29th ult was examined on the 17th December. The gas was carefully collected in a test tube and amounted to about 14 c.c. It was divided into two parts and each after mixing with atmospheric air gave the characteristic hydrogen pop on applying flame. The solution was distinctly acid. 90% of this hydrogen should be produced by the decomposition of the free H_2SO_4 in solution by zinc then the amount of zinc dissolved to produce 30 c.c. in one month of H^2 would be 50 milligrammes.

Motor Experiments contd:—

6th December 1911 Tuesday

Motor test interrupted. Took down bottle, weighed plates as follows.

No. of bott.	No. of plate	Motor	Mean temp	When started	Weight empty	Sum.	Joint weight	Weight in air	Loss	Gain
LXXXI	1	Std #2	26·5	18 11 12.55	84·6815	169·1178	169·1195	85·0922		0·4407
	2				84·4663			84·0170	0·4493	
LXXII	3	Special			89·3116	176·0759	176·0767	89·7527	0·4411	
	4				86·7643			86·3110		0·4633
LXXIII	5	Special			84·3337	168·1672	176·1680	84·7892	0·4555	
	6				83·8335			83·3677		0·4658

	Loss cell for short circ	Error of Special meter	Gain in Gain by Calculation	Load		
In this experiment no smutting was observable. But of the two bottles set in a commercial meter in refrigerator # LXXXI and LXXXII one with 1·05% and the other with 1·11 solution the denser solution bottle showed some smutting.	0·4502		0·0083			
	0·4411	0·9799 = 2%	0·0125	10 ampères		
	0·4483	0·9958 = 0·4%				
	0·4555	1·0120 = 1·2%	0·0102			

To ascertain whether the cast zinc had any less density than the rolled zinc, took one of Bergmann's zincs, two of our cast 5% zincs and one cast freshly today from Bergmann's zinc melter up for the purpose.

No.	Quality	Amalgam	alloy Hg	Weight in air	Weight in water	Difference	Sp. g.			
1	new Bergmann bottle	new	0%	104·0141	89·375	14·666	7·094			
2	Laboratory cast	new	0%	83·719	71·920	11·799	7·095			
3	Bergmann bottle	new	0%	81·890	70·245	11·645	7·032			
4	Bergmann spiral wound new	new	0%	114·363	98·473	15·890	7·197			

To test the effect of acidity of solution on the resistance and on the smutting took some s.p. dense $ZnSO_4$ solution and reduced it neutral by the addition of $Zn(HO)_2$. Took some of the same original solution and left it with the original distinct acid reaction but of same density as the neutral. 2 Bottles 84 and 85 were made up with the neutralized solution 1·075 sp.g., bottles 86 and 87 were prepared with the acid solution 1·075 sp.g. all four heated to boiling point, and fitted with Bergmann zincs amalgamated hot with hot mercury. 84 and 86 were started with 78 79. 80 and 81 in a smutting test at 16 o'clock with 200 milliampères. The four bottles had their solutions filtered and heated with the zincs filed and amalgamated. Bottles 85 and 87 were set aside.

$$78{\cdot}21\,(1+x)^{16{\cdot}6} = 83{\cdot}20$$
$$(1+x)^{16{\cdot}6} = \frac{83{\cdot}20}{78{\cdot}21} = 1{\cdot}064$$
$$1+x = \log^{-1}\left(\frac{0{\cdot}0269446}{16{\cdot}6}\right)$$
$$= \log^{-1} 0{\cdot}0016229$$
$$= 1{\cdot}00376$$

$$83{\cdot}2\,(1+x)^{66{\cdot}2} = 99{\cdot}85$$
$$(1+x)^{66{\cdot}2} = \frac{99{\cdot}85}{83{\cdot}2} = 1{\cdot}20012$$
$$1+x = \log^{-1}\left(\frac{0{\cdot}0793246}{66{\cdot}2}\right)$$
$$= 0{\cdot}0011967$$
$$= 1{\cdot}00276$$

$$78{\cdot}21\,(1+x)^{82{\cdot}8} = 99{\cdot}85$$
$$(1+x)^{82{\cdot}8} = \frac{99{\cdot}85}{78{\cdot}21} = 1{\cdot}2767$$
$$1+x = \log^{-1}\left(\frac{0{\cdot}1054889}{82{\cdot}8}\right)$$
$$= 0{\cdot}0012812$$
$$= 1{\cdot}00295$$

Boston, Dec 17, 1888.

Reels No.	13 Results Meter No. 305 One side 25 Dl. bottle + fluid Other " 100 Dl. " " " Deflection	Deflection	Resistance	13 Results All 100 Dl. bottles + fluids Resistance	A side	B side
1.	.250 gp	1.023 gp	1.120 gp	.885 gp	.805 gp	
2.	.303	1.150	1.212	.725	.710	
3.	.345	1.273	1.380	.595	.565	
4.	.358	1.410	1.432	.650	.605	
5.	.335	1.385	1.340	.595	.505	
6.	.343	1.363	1.372	.570	.590	
7.	.348	1.328	1.392	.570	.545	
8.	.374	1.388	1.500	.960	1.170	
9.	.305	1.213	1.232	.870	.890	
10.	.275	1.075	1.100	.945	.945	
11.	.235	.910	.957	1.040	1.030	
12.	.298	1.140	1.192	.450	.850	
13	.265	1.045	1.072	.615	.610	

13 Results Meter No. 306 One side 25 Dl. bottle + fluid Other " 100 Dl. " " " Deflection	Deflection	Resistance	13 Results All 100 Dl. bottles + fluids Resistance	A side	B side
.370 gp	1.093 gp	1.294 gp	1.075 gp	1.085 gp	
.323	1.273	1.292	.625	1.125	
.320	.948	.980	.895	.970	
.338	.865	1.332	.970	1.030	
.365	1.403	1.460	1.215	1.350	
.349	1.358	1.372	.940	.920	
.350	1.160	1.400	.770	.700	
.313	1.613	1.252	.960	.930	
.365	1.333	1.460	.850	.835	
.325	1.260	1.312	.715	.715	
.270	1.060	1.050	.630	.645	
.333	1.320	1.332	.650	.575	
.300	1.225	1.200	.410	.470	

(62)

(6) December 19th Wednesday

Meter Experiments contd:

Interrupted the meter bottle smuttering test that was commenced yesterday afternoon, at 15 o'clock, after 23 hours duration at 0.2 amp. On opening the bottles and examination there was slight evidence in favour of the supposition that the degree of smuttering diminished with the density and with the acidity of the solution, but not sufficiently marked, to warrant such a statement.

To measure the coeff. of temp. of copper, wound about 8 metres of fine silk covered copper wire diam: 0.002" = 0.004458 cm on an ebonite X spool and took its res: at three temperatures as follows:—

No. of Obs.	T.B.	Bridge	Res. of Std. coil for bridge	Temp. of Spool	Difference of Temp.	1+x	Coeff.	Best result	
1	25·2°C.	1000/10	83·20	24·6°C.					
2	25·4°C	-	78·21	7·2°C	16·6°	0·00376	0·376%	0·276%	
3	25·5°C	.	99·85	90·2°C.	66·2°	0·00276	0·276%		
					82·8°	0·00295	0·295%		

The results from the high temperature variation are not reliable owing to the variability of the temperature in the incubator.

The resistance of bottle [XXXVII] made up yesterday acid 1.750
[XXXVI] " " " neutral 1.850

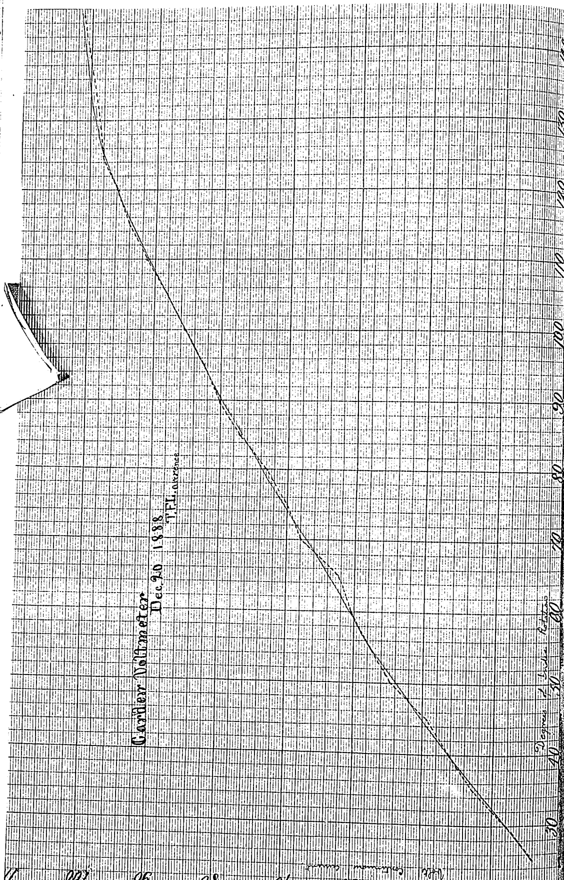
both [XXXVI] had leaked somewhat through a fresh crack but it was distinctly noticeable that the surface of the acid solution gives had bubbles on them while that of the neutral solution had none.

(7) December 20th Thursday.

For the measurement of the average resistance of different bottles wound 12 small spools of #26 B.W.G. G.S. wire and measured their res: by deflection method and comparison with the standard ohm at 24·6°C. Results as follows:— Res. of 1 = @ 24·6 = 1·0027 F.Z 275

No. of coil	Temp. of coil	Defl. on coil @ 24	Defl. on 1 = 24	Res. of coil @ 24·6°C	No. of coil	Temp.	Defl. on bot. @ 24	Defl. on 1 = 24	Res. of coil @ 24·6°C	
1.	24·6°	275 + 248	275 + 243·5	2·023	7	24·6°	275 + 245	275 + 243·5	2·012	
2		249·5	243·5	2·029	8		249	243·5	2·027	
3		248	243·5	2·023	9		248·7	243·5	2·026	
4		255·5	243·5	2·052	10		247·5	243·5	2·021	
5		236·5	243·5	1·978	11		248	243·5	2·023	
6		239·5	243·5	1·990	12		248	243·5	2·023	

On the opposite page appear some results given by Mr Edgar through Mr Wint relating to the behavior of 25 cl bottles in 100 cl meter.



Meter Experiments contd:—

December 20th. Thursday

Finding that bottle # 47 remained in good condition and that it gave off bubbles of gas on the zinc plates, prepared a solution to test its degree of acidity. Took 10 c.c. of Wilmoski's normal NaOH solution and diluted it with 90 c.c. of H_2O dest: thus making a 10% normal solution. Took 10 c.c. of the solution from # XLVII in a test tube and found that it ~~took~~ required the addition of some 35 drops of 10% N.S. to produce permanent turbidity.

Ordinary meter solution seems to vary in acidity as prepared for our carboys. The lowest test that has been made is 5 drops of 10% N.S. to 10 cc. with permanent precipitate

Set up four bottles # 92 93 94 and 95 for the purpose of measuring their resistance at a certain temperature.

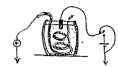
No. 92 had plain zincs amalgamated hot in boiled solution 1.054 5 drops 10% NS. P.P.
- 93 - - - - - - - - - with 2 drops of H_2SO_4 added
- 94 - - - - - - - - - - 4 - - - -
- 95 - - - - - - - - - - 6 - - - -

No. 92 will take the whole current say 10 mamps and the others will each be shunted by a spool.

December 21st Friday.

Tested the Simins 1000 feet of double conductor torpedo cable and found the insulation O.K.

This 1000 feet length was coiled on a hollow form and submerged in a barrel of water standing on the outer room floor.



On connecting the outer conductor of the cable with the 5th table astatic galvr: grounded as shown, and inserting a small strip of copper into the water, the depression of the key above 1 AgCl: cell produced a throw whose mean amount was 58 divs:

December 22nd Saturday.

Made up four more 25 lt bottles as follows.

No. 96 had plain zincs amalgamated hot, in boiled solution 1.054 20 drops P.P.
- 97 - - - - - - - - - -
- 98 - - - - - - - - - -
- 99 - - - - - - - - - -

No. 96 will take the whole current, while the others will be shunted by spools.

The 92 – 95 group were mounted in a box over the steampipe and supplied with a lamp. The temperature of the air round the bottles was about 32° C on starting.

The 96 – 99 group were mounted in the refrigerator.

The temperature was about

The weights of the plates in these bottles are given on the following page.

Bottle No.	Plate No.	Plate	Amalgamated	Solution	Acidity	Current & date of performance	Shunted by	Weight empty	Joint weight	Difference
92	1	Plain unamalgamated Zinc	In mercury heating under boiling water after being thoroughly washed in boiling water	Repeat over and with fresh joint	5 drops N.S. R.P.	0.01 amp	—	87.2212	167.9210	+0.0006
	2							80.6992		
93	3				do. + 2 drops N/R	21.12.88	(1) 2.023 @ 24°	74.3649	155.5317	+0.0002
	4							81.1664		
94	5				do. + 4 . . .		(2) 2.023 @ 24°	77.8895	167.5540	+0.0005
	6							89.6640		
95	7				do. + 6 . . .		(3) 2.023 @ 24°	70.4122	157.9070	+0.0002
	8							87.4948		
96	1				20 drops N.S. R.P.		—	86.9974	153.8427	+0.0002
	2							66.8451		
97	3				- - - .		(1) 2.030 @ 24°	90.5405	178.5276	+0.0009
	4							87.9862		
98	5				- - - .		(2) 1.978 @ 24°	80.3833	165.6370	+0.0004
	6							85.2523		
99	7				- - - .		(3) 2.026 @ 24°	86.2962	161.8054	-0.0005
	8							75.5097		

Experiment to determine the electrochemical equivalent of zinc.

Three pairs of zinc plates were selected.

Plates 1 + 2 were of 0% pure electrolytic cast zinc, unamalgamated

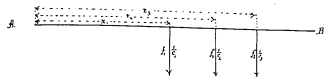
- 3 + 4 - - 5% Hg alloy) unamalgamated pure electrolytic zinc cast
- 5 + 6 - - 5% - - was amalgamated and used.

The solution was 1·11 sp. g. $ZnSO_4$, acidity 10 drops, raised to boiling point. These plates were set in 25 ct bottles but were not coupled by rubber connectors as in the ordinary meter bottle. No stoppers were placed on the bottles, which were in series with each other and a silver voltameter formed of a small glass beaker containing pure $AgNO_3$ and small silver plates about 6·5 sp. one in each dipping into it. The 4 voltameters were connected with a storage cell and resistance box with the British galvo. The test commenced about at 18.05 19.12.88 the current being steadily maintained at 10 m. amps, and the temp. of the room averaging about 20°C. All went well up to the evening of the 21st but on the morning of the 22nd the current was found interrupted by the fracture of the anode in the silver voltameter which had been allowed to dissolve too far and the dust debris of which had fallen to the bottom of the beaker. The following are the weights obtained by Mr Lawrence. The gain could not be obtained since the zinc cathodes had smutted.

Bottle No.	Metal	Weight empty 19.12.88	19.12.88 Sum	Observed joint weight	Difference	Weight empty 22.12.88	Loss	Gain	Ratio Zn to Ag	Chem. Eq.	Chem. Eq. of Zn
1	0% Zn	~~106.7577~~ 106.3297	215.0836	215.0836	+0.0002	106.1318	0.6219	—	0.29602	0.00032 Ag 3.310 × 10⁻⁴	63.709
2											
3	5% Zn amal.	121.8911	236.1613	236.1620	+0.0007	113.9231	0.6471	—	0.30502	3.442 × 10⁻⁴	66.323
4		114.5702									
5	5% Zn amal.	117.6819	229.2696	229.2698	+0.0002	117.0178	0.6641	—	0.31611	3.5385 × 10⁻⁴	68.085
6		111.5877									
7	Ag.	2.8168	5.9279	5.9278	−0.0001	0.7180	2.1098				
8		3.1091				5.2100	~~2.10~~ 2.1009				

The zinc were unmanished, and not heated or amalgamated before the test under these circumstances they would be liable to gain weight by oxidation the tendency being greatest in 1·2 Cent in 5 ct. To arrive at the loss of the silver plate, the debris in the beaker had to be collected and dried on a watch glass.

General Mathematical theory of the resultant fault determination in a circuit of known derivations.



Let AB be a conductor such as a telegraph line with derivations of $c_1\ c_2\ c_3 \ldots c_n$ who at distances $x_1\ x_2\ x_3 \ldots x_n$ ohms from A

Then let R be the insulation resistance from A

" " ρ " Part part of the insulation res: due to the resultant fault

" " X " " " " " " " " " resultant distance

Thus $R_x = \rho_x + X_x = x_1 + \frac{1}{c_1}$

Also $R_2 = x_1 + \dfrac{\frac{1}{c_1}(x_2 - x_1 + \frac{1}{c_2})}{\frac{1}{c_1} + \frac{1}{c_2} + x_2 - x_1}$

$= x_1 + \dfrac{c_2 x_2 - c_2 x_1 + 1}{c_1 + c_2 + c_1 c_2 (x_2 - x_1)}$ and since $(x_2 - x_1)$ is small and $c_1 c_2$ is also small we have approx:

$= \dfrac{c_1 x_1 + c_2 x_1 + c_1 x_2 - c_2 x_1 + 1}{c_1 + c_2}$

$= \dfrac{c_1 x_1 + c_1 x_2}{c_1 + c_2} + \dfrac{1}{c_1 + c_2}$

Also $R_3 = x_1 + \dfrac{\frac{1}{c_1}\left((x_2 - x_1) + \frac{1}{c_2}\left(x_3 - x_2 + \frac{1}{c_3}\right)\right)}{\frac{1}{c_1} + x_2 - x_1 + \frac{1}{c_2}\left(x_3 - x_2 + \frac{1}{c_3}\right)}$ simplifying and rejecting terms of the order $\Delta x\, c$ or $\Delta x c^2$ we have

$= x_1 + \dfrac{c_1 x_1 + c_1 x_2 - c_1 x_1 - c_1 x_2 + c_2 x_3 - c_2 x_2 + 1}{c_2 + c_3 + c_1}$

$= \dfrac{c_1 x_1 + c_2 x_2 + c_3 x_3}{c_1 + c_2 + c_3} + \dfrac{1}{c_1 + c_2 + c_3}$

Hence by induction

$$\left.\begin{aligned} \rho_n &= \frac{1}{\Sigma c} \\ X_n &= \frac{\Sigma cx}{\Sigma c} \\ \text{and } R_n &= \frac{\Sigma cx}{\Sigma c} + \frac{1}{\Sigma c} \end{aligned}\right\}$$

To a degree of approximation which increases with the number of derivations, and becomes rigidly true with an infinite number.

Also for a return circuit system the formulae become

$\rho_n = \frac{1}{\Sigma c}$

$X_n = \frac{\Sigma c\, 2x}{\Sigma c} = 2\,\frac{\Sigma cx}{\Sigma c}$

$R_n = 2\,\frac{\Sigma cx}{\Sigma c} + \frac{1}{\Sigma c}$

To repeat the measurement of the electrochemical equivalent of zinc the following experiment was arranged on the 24th and 25th December. Five couples of zinc and one couple of silver. The silver voltameters were formed of 2 silver plates each about 8×5 cm. wide and with the upper edge so cut that by bending it formed a triangle thus:— A silver wire passed through the triangle and depended upon the weight of the plate for contact. These plates were immersed in a 25% solution by weight of $AgNO_3$ prepared by adding 50 grs. pure $AgNO_3$ to 150 of distilled water.

The zinc cells were either 12 light bottles or 25 light tubes. The latter proved very fragile & couple #3 & 4 were upset through a fracture. The zincs were new 5% castings doubly amalgamated. They were amalgamated after boiling in hot mercury on the morning of the 24th. They were then left in the desiccator till the 25th when they were weighed and immersed the last being weighed at 23 o'clock. The solution was 1·054 $ZnSO_4$ from the chemical room acidulated until it took 35 drops of standard 10% solution (see page 63) to produce P.P. It was then boiled in a porcelain dish and then poured off into a stoppered bottle where it remained for 24 hours until required for use. The circuit through the 6 voltameters was closed through a storage cell, ammeter galvo: and 250Ω at 23h5m. 25.12.88— the current being 7 amp.

No.	Metal	Amalgam	Solution	Weight at 23h	Sum.	Joint weight	Discrepancy
1	5% cast zinc (Mercury)	amalgamated over night & dried in cold mercury boiling until hot	pure $ZnSO_4$ density 1·054 before boiling with H_2SO_4 added until 35 drops of standard solution required to produce P.P. then boiled in porcelain dish & poured off into a stoppered bottle where it remained for 24 hours until required for use	115·3053	234·7496	234·7496	0·0000
2				119·4443			
3				113·9077	233·8539	233·8543	+ 0·0004
4				119·9462			
5		amalgamated over night & dried in cold mercury boiling until hot		121·2429	238·7328	238·7335	+ 0·0007
6				117·4899			
7	pure zinc cast with 5% (Mercury) of distilled			116·8968	233·3804	233·3810	+ 0·0006
8				116·4836			
9				127·7305	251·9335	251·9343	+ 0·0008
10				124·2030			
11	Silver strip	New	25% sol: pure $AgNO_3$	8·3465	16·6409	16·6403	− 0·0006
12				8·2944			

December 26th Wednesday

Made up two new bottles as follows—

(1) 5% cast zinc unvarnished. Amalgamated hot in hot mercury. Solution 1·054 18 drops P.P. boiled. 25 lt bottle.

(2) 5% cast zinc unvarnished. Amalgamated cold in cold mercury. Solution 1·054 18 drop P.P. boiled. 25 lt bottle.

The only difference known lies in the amalgamation.

No. (1) developed speedily bubbles on its surface. No 2. speedily tarnished.

Commenced report on Meter work.

Measured the spec. res: of a saline solution made by adding 35 grs. $NaCl$ to 1000 grs. Infusion. The sp. gr. of the mixture was about 1·027 (at about 20°C temp. The resistance of a tube column 166 cms long and 1·105" = 2·81 cm. diam: was 7400. On cooling by ice application to 5°C. the res: fell to 8200 = 30·6 sp. res. The conditions of this measurement did not ensure any great degree of precision. The electrodes were of amalgamated zinc.

$R\,(1.00388)^{19} - R = 1.476\omega \qquad R = \dfrac{1.476}{(1.00388)^{19} - 1}$

$\log 1.00388 = 0.0016828 \times 19 = 0.0319732 = \log^{-1} 1.0764$

$1.476 \div 0.0764 = 19.3\omega$

$\therefore\ 1.005 = 0.0021661 \times 19 = 0.041159 = \log^{-1} 1.0993$

$1.476 \div 0.0993 = 14.86\omega$

Meter Experiments contd:—

To ascertain whether the strong current (averaging during working hours 50 amperes and reaching at times 100 amperes) passing through the platinoid strip mentioned on page 58 and placed in cot. with the compositions motor since the 13th inst. have caused any change in its res: I took it down and measured it as follows:—

2 Daniells bn in cot with legal 0·1ω and strip @ 18·8°C.

After the measurement the strip was replaced in the motor cot.

No. of Obs	Defl. on strip 332·4	Defl. on 0·1ω 336·0	Ratio strip to 0·1ω	Res. of strip @ 15°C	Res. of strip @ Temp	v	v²	0·6745 $\frac{\sqrt{v^2}}{\sqrt{n(n-1)}}$	Res. of strip @ 18°C	Res. @ 22·5°
1	338·9	337·0	0·99888	0·1000	0·099888	−0·000022	4·44 × 10⁻¹⁰	0·19471 × 0·0002	0·09965 ± 0·00004	0·09973
2	334·9	336·0	0·99635		0·099635	+0·00019	13·69 × 10⁻¹⁰	19471 × 0·00023		
3	333·9	336·7	0·99580		0·099580	−0·00004	1·69 × 10⁻¹⁰	1·47 × 10⁻⁵		
4	334·3	336·7	0·99649		0·099649	−0·00001	1 × 10⁻¹⁰	0·00004		
Mean	334·25	336·6	0·99647		0·099647	−0	5·3558 × 10⁻¹⁰ / 23·69 × 10⁻¹⁰ / 0·00023			
					0·09964					

The present res: referred to 22·5° is 0·09973ω ± 0·00004

" previous " " " was 0·09988 ± 0·00001

Difference 0·00015 = 0·15 % about 1/6 of 1%.

December 28th Friday. Interrupted at 8·20 the meter resistance test, dried and weighed the plates as follows:—

No. of Plate	Weight empty 22.12.88	Joint plate weight 22.12.88	Average temp	Shunted by a wire	Res. of shunt @ mean temp	Hydrometer reading under 4 corks	Weight empty 28.12.88	Sum	Joint weight 28.12.88	Joint gain	Joint loss
1	87·2212	167·9210	27°C	∞	∞	10	85·8230	167·9686	167·9688	0·0478	
2	80·6992						82·1458				
3	74·3849	155·5317	27°	2·023	2·025	20	74·8804	155·4945	155·4950		0·0367
4	81·1468						80·6141				
5	77·8987	167·5840	27°	2·023	2·025	10	78·7132	167·6104	167·6108	0·0568	
6	89·6853						88·8972				
7	70·4122	157·9070	27°	2·023	2·025	50	70·9577	157·7265	157·7260		0·1810
8	87·4948						86·7688				
9	76·9976	153·8427	7°	∞		20	85·5418				
10	66·8451						omitted				
11	90·3405	178·5276	7°	2·029	2·013	20	90·6275	178·4839	178·4843		0·0433
12	87·9863						87·8564				
13	80·3833	165·6370	7°	1·978	1·963	20	80·4742	165·5863	165·5864		0·0506
14	85·2523						85·1121				
15	86·2962	161·8054	7°	2·026	2·010	20	86·3331	161·7511	161·7515		0·0539
16	75·5097						75·4180				

No. Plate	Individual gain	Individual loss	Excess of gain over loss	Excess of loss over gain	Ratio of gain & loss to loss	Coefficient Electrolytic	Calculated Mean Res.	Mean Res.	Undivided current	Hours of Flow.	Appearance of Plate
1	1·46733	1·8982									dull
2	1·44666		0·0482								clean
3	0·5755										brilliant
4		0·6627		0·0368	2·531	1·531	3·10ω				clean
5	0·8237		0·0569								clean
6		0·7668			1·824	0·824	1·67ω	2·22ω			dull
7	0·5395										brilliant
8		0·7288		0·1813	1·940	0·940	1·90ω				dull
9	—	0·4556							10 microamps	94 hours + 20 hour intermission or 114 in all.	dull
10											bright
11	0·2870			0·0429	11·22	10·22	20·57ω				bright
12		0·1298									bright
13	0·0909			0·0493	10·38	9·38	18·41ω	22·9507			bright
14		0·1402									clean
15	0·0369			0·0548	15·87	14·87	29·8ω				bright
16		0·0917									clean

Motor Experiment, contd :-

December 29th Saturday :-

The last resistance test not having been very successful, arranged to repeat it as follows :-

The same zincs were raised to boiling point of water and amalgamated in fresh hot mercury. The solution 1·0544 was raised to boiling point in a large porcelain dish, and poured into the bottles as soon as possible. The tops of the bottles were then put on so that the solution might cool down without free access to the air. The density of the solution was found afterwards to have been increased to 1·065 on cooling, but it was not altered in the bottles. The weights were then taken as follows :- Observer Lawrence.

No. of plate	Weight before	Sum	Joint weight Ind.	Discrepancy	Bottle Bottles Nos	Shunted by @25°C	Acidity of solution	Current	Group
1	78·7310	142·3715	142·3712	− 0·0003	1-2	∞	10-15	0·009 amp	
2	63·6405								
3	94·1786	157·5915	157·5928	+ 0·0013	3-4	(1) 2·023			Warm
4	73·4159								
5	84·2353	150·8535	150·8555	+ 0·0020	5-6	(11) 2·023			
6	66·6182								
7	81·0620	167·3760	167·3760	+ 0·0015	7-8	(3) 2·023			
8	86·3125								
9	70·0398	149·5188	149·5192	+ 0·0004	9-10	∞			
10	78·6790								
11	78·4648	164·0258	164·0260	+ 0·0002	11-12	2 2·029 5 1·978 9 2·026 } 6·043			Cold
12	82·5610								
13	84·9529	173·3901	173·3906	+ 0·0005	13-14	4 2·002 6 1·990 12 2·023 } 6·015			
14	88·4372								
15	82·2462	177·7167	177·7175	+ 0·0008	15-16	7 2·012 8 2·027 10 2·021 } 6·060			
16	85·4505								

The current used in operation on these bottles at 21 o'clock.

Electrochemical equivalent Test:

The series of bottles started on the 25th were kept in operation on 7 minutes till the evening of the 28th when the current was reduced to 1 milliamp on account of the freezing on the silver cathode endangering the liquid circuit. The plates were removed and washed on the 29th in the morning and weighed the same evening. It was noticeable that although the freezing on the silver cathode extended near the top of the plate to about a perpendicular distance of 1 cm, the hard deposit clung firmly and did not seem to be shaken off by gentle washing. Weights as follows :-

No. of plate	Weight before 25.11.11	Joint weight 25.11.11	Weight after 29.11.11	Joint weight Sum	Joint weight Ind. 29.11.11	Gain	Loss	Mean of Gain − Loss	Elect. Equiv.
1	115·3053	234·7496	114·8389	234·6713	234·6707	~~0·0336~~	0·6664 0·6953	0·4273	0·396 x10⁻⁴
2	119·4443		119·8324			0·3881			
3	113·9077	233·8543	113·4204	233·7408	233·7405	0·3742	0·4873 0·1141	0·4308	3·424
4	119·9466		120·3204						
5	121·2129	236·7335	120·7560	238·6187	238·6188	0·3728	0·4569 0·1141	0·4299	3·417
6	117·4899		117·8627						
7	116·8968	233·3810	116·4050	233·2555	233·2555	0·2669	0·4218 0·1437	0·4294	3·413
8	116·4836		116·8505						
9	127·7305	251·9343	127·2400	251·8163	251·8165	0·3729	0·4906 0·1177	0·4315	3·430
10	124·2030		124·5759						
Ag 1	8·3465	16·6403	9·7493	16·6353	16·6353	1·4025	1·4056	1·4056	
Ag 2	8·2944		6·8860						
							Mean	0·4298	3·416 x10⁻⁴

The mean value is 0·0003416, but the couple that lost least (1-2) give 0·0003396. Ayrton's number is 0·0003393.
The mean difference from Ayrton's number is 0·7% and from 1-2 0·1%, the greatest error 1·2%.

Germicide experiments. continued from page 36.

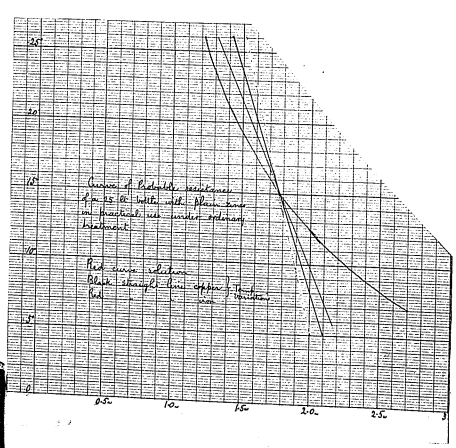
A series of experiments with caustic soda on the 12th December.
Prepared some Buchholtz Nutrient fluid as follows.

Phosphate of Potash 1 gr
Tartrate of ammon. 2.
Rock candy 20.
Distilled water 200.

Introduced this solution into 5 test tubes after sterilizing it by boiling repeatedly.

No. of tube	Weight of NaHO in tube	Weight of Buchholtz Nutrient	%	Date of first discovery of organisms	Remarks
1	0	50	0	Dec. 19th — 7 days	All these tubes were closed with corks but were opened almost daily for examination
2	0.5	49.5	1	" 21st — 9 "	
3	1.0	49	2	" 27th — 15 "	
4	4.0	46	8	" 29th — 17	
5	8.0	42	16	" still clear 31-12-98	

On the 31st Dec. the condition of these tubes is as follows:—
No. 1. Cloudy with thick white pellicle on the surface
" 2 Clear with amber color and contains a few live bacteria + budding cells
" 3 " " " " " fewer
" 4 " " " " " very few
" 5 " " " " " no visible " or



Meter Experiments contd.
December 31st Monday.

Set the electrolytical equivalent test to work at 16·30 relech. on 0·2 amp. Weighed plates carefully, filled the $AgNO_3$ solution, and prepared the Zn SO_4 solution by taking a solution of 200 grammes Powers & Weldemann salt added to some 1866 c.c. ag. dist. Their density was 1·085 before boiling in porcelain dish, after which 1307 c.c. were received at 1·087. The zinc were amalgamated in hot mercury, after dipping in boiling water. They were then chilled in cool water. Couples 1-2 3-4 7-8 9-10 were in circuit with the silver voltameter, and 5-6 was left in solution to examine the separate gain or loss.

Plate No.	Weight surfs before	Mean.	Mid point weight before	Weight surfs after	Sum.	Mid point weight after	Gain	Loss.	Difference	E.C. Equiv
1	116·3742	236·3410	236·3444	117·7745	236·3011	236·3020	1·4203			
2	119·9669			118·5266				1·4402	−0·0399	3.326×10^{-4}
							1·420			
3	119·4594	232·7214	232·7247	120·8915	232·7187	232·7197				
4	113·2620			111·8272			1·4321	1·4378	−0·0057	3.361
							1·435			
5	124·1676	244·6642	244·6645	124·1679	244·6562	244·6570				
6	120·5166			120·5083			0·0003	0·0053	−0·0050	~~3.235~~
7	112·8265	232·3575	232·3578	116·2658	232·3513	232·3520				
8	117·5310			116·0855			1·4393	1·4455	−0·062	3.335
							1·434			
9	116·0127	242·8635	242·8640	117·4517	242·8655	242·8660				
10	126·8508			125·4138			1·4390	1·4370	+0·0020	
							1·438			3·369
										Mean 3·348 $\times 10^{-4}$
Ag 1	8·3252	15·1517	15·1517	3·2850	14·9550			5·0704		
Ag 2	6·8263			11·6000			4·77374			
							4·7737			

The deposit on the zinc was homogenous and good. The silver plate anode was much consumed and lost a considerable quantity of black powdery material, which was however collected on a watch glass and found to amount to 54 mgrms. A small piece was lost of the gain on the cathode but an estimated quantity representing it was weighed and represented 34 mgrms. These corrections are introduced into the above figures. Taking the gain of the silver the mean elect. chem. eq. is 3.348×10^{-4} or 1·205 per amp. hour. Taking the mean of gain and loss. 3.442×10^{-4} or 1·242 - - - - The results are unsatisfactory as regards the silver voltameter.

January 2nd 1889 Wednesday

Interrupted the meter resistance with the following results.

Plate No.	Weight surfs 29.12.88	Sponge temp	Shunted by 0·25°	Res. of Shunt (0 mean 6.0)	Weight surfs 2.1.89	Sum of pairs	Mid point weights 2.1.89	Gain	Loss.	Res Ratio	Res
1	78·7310	26°	∞		78·5273	142·3421	142·3420	0·7143	0·2037		
2	63·6105				63·8148						
3	84·1756	26°	2.023	2.025	84·6658	157·5690	157·5692	0·4899	0·5124	1.612	1.239
4	73·4134				72·9035			0.50			
5	84·2323	26°	2.023	2.025	84·7675	150·8080	150·8085	0·4822	0·5277	1.601	1.217
6	66·6162				66·0405			0.50			
7	81·0620	26°	2.023	2.025	81·5446	167·3314	167.3320	0·4826	0·5257	1.608	1.221
8	86·3125				85·7868			0.50			1.226
9	70·9298	T	∞		71·6214	149·8663	149·8667	0·7816	0·8341		
10	78·6790				78·2449			0.783			
11	78·6648	T	6.043	6.00	78·9910	160·9865	160·9868	0·5262	0·5655	1.480	2.880
12	82·2610				81·8955			0.50			
13	84·9520	T	6.065	6.02	85·5010	173·3516	173·3519	0·5481	0·5866	1.4224	2.553
14	88·3972				87·8506			0.548			
15	82·2662	T	6.060	6.02	82·8273	167·7192	167·7196	0·5611	0·5586	1.4243	2.673
16	85·4505				84·8919			0.559			
											2.702

Highest temp. for January 57° } 45° Range
Lowest - - - 12°
Maximum Rainfall - - 1.47"
Highest Bar. reading - - 30.281"
Lowest - - - - 29.370"
Range 0.911"
Total Rainfall 5.05"

Highest temp. for February 50°F } 50° Range.
Lowest - - 0°
Maximum Rainfall 0.98"
Highest Bar. reading 30.614"
Lowest - - - 29.346
Range 1.268"
Total Rainfall 2.21"

Meteorological Record commencing 1st Jan. 1889.

Month	Day of Month	Time	Barometer Reading Eng.	Barometer Reading Cmm.	Temp. of Air Fahr.	Reduced Bar. Eng.	Reduced Bar. Cmm.	Rep. at 32°F	Max. Temp. Max.	Min. Temp. Min.	Dry Bulb Temp. Day	Wet Bulb Temp. Wet	Rainfall Eng.	Remarks
January	1st	Noon	29.946	76.07	78°	29.810		75.73	36°	23°	40°		0.	Fair Cum. Strats
"	2nd	"	29.870	75.87	76°	29.740		75.46	30°	23°	29°		0	Cloudy, Nimbus
"	3rd	"	30.086	76.42	74.5°	29.963		76.10	29.5	29°	29°		0	Fair Light Mist Clo.
"	4th	"	30.100	76.46	78°	29.962			32°	32°	32°		0	
"	5th	"	30.058	76.26	78°	29.999			49°	31°	49°		0.05	Wet. Nimbus NE.
"	6th	"	29.545	75.05	70°	29.433			42	38	41°		1.47	Rain Nimbus NE.
"	7th	"	29.500	74.93	73°	29.377			42	37	40		0.31	Rain Nimbus NW.
"	8th	"	29.778	75.64	69°	29.667			43	35°	43		0.01	Fair Clear
"	9th	"	29.430	74.76	62	29.376			45	30	44		0.58	Rain Twist
"	10th	"	29.648	75.31	50°	29.594			57	34	39		0.42	Fair Cu. Cum. Strat.
"	11th	"	30.029	76.27	58°	29.951			42	31	37		0.0	Fair Nimbus W. mist
"	12th	"	30.232	76.79	66°	30.130			39	28	34		0.0	Fair Clear W. hazy
"	13th	"	30.248	76.83	62°	30.158			35	20	34		0.0	Fair Clear
"	14th	"	30.236	76.80	63°	30.143			36	24	36		0.0	Fair cloudy
"	15th	"	30.336	77.06	57°	30.281			37	19	29		0.0	Fair Clear
"	16th	"	30.134	76.54	58°	30.056			37	26	37		0.0	Fair Clear.
"	17th	"	29.576	75.13	72°	29.456			56	37	56		1.05	Rain. SW. mist
"	18th	"	29.806	75.71	70°	29.692			47	22	40		0.00	Fair Clear NW.
"	19th	"	30.314	77.00	62°	30.224			46	25	28		0.	Fair Clear NW.
"	20th	"	30.292	76.94	37°	30.277			27	15°	21		0.	Cloudy
"	21st	"	29.438	74.78	47°	29.393			29	21	36		0.55	Snow
"	22nd	"	30.306	76.98	60°	30.222			34	25	31		0.	Clear
"	23rd	"	30.400	77.21	52°	30.340			34	12	34		0	Cloudy
"	24th	"	30.186	76.68	53°	30.123			39	16	39		0	Cloudy
"	25th	"	29.984	76.17	50°	29.930			40	28	39		0.03	Fair
"	26th	"	29.910	75.97	48°	29.862			43	24	42		0	Overcast
"	27th	"	29.231	74.26	52°	29.168			45	34	45		0.55	Overcast
"	28th	"	29.414	74.71	47°	29.369			36	24	25°		0	Clear
"	29th	"	30.004	76.22	55°	29.935			28	17	17		0	Clear
"	30th	"	29.773	75.62	60°	29.699			40	20	39		0	Clear
"	31st	"	29.802	75.70	49°	29.751			45	28	98		0.01	Clear
Febry.	1st	"	29.722	75.50	56°	29.650			34	19	34		0.0	Clear
"	2nd	"	29.472	74.91	46°	29.410			39	31	39		0.0	Clear
"	3rd	"	29.848	75.80	56°	29.776			39	11	24		0.0	Overcast
"	4th	"	29.460	74.84	70°	29.346			43	25°	25°		0.0	"
"	5th	"	29.602	75.20	62°	29.512			44	16	18		0.10	Cloudy
"	6th	"	29.870	75.86	57°	29.795			20	10	20		0.0	Cloudy
"	7th	"	29.984	76.17	58°	29.906			30	10	30		0.0	Overcast
"	8th	"	29.856	75.84	68°	29.748			36	21	36		0.08	Clear
"	9th	"	30.006	76.25	45°	29.967			39	21	35		0.0	Cloudy
"	10th	"	29.724	76.00	62°	29.636			39	17	32		0.0	Overcast
"	11th	"	29.606	75.21	59	29.525			32	22	29		0.07	Clear
"	12th	"	29.610	75.22	50°	29.541			30	12	19		0.	Clear
"	13th	"	29.884	75.91	52°	29.818			24	10	24		0.	Clear.
"	14th	"	30.224	76.77	63°	30.131			32	11	32		0.	Clear
"	15th	"	30.154	76.59	65	30.055			49	32	32		0	Rain
"	16th	"	29.504	74.95	47	29.459			44	33	44		0.98	Rain
"	17th	"	29.[illegible]	76.00	60	29.879			44	34	35		0.56	Rain
"	18th	"	29.924	76.00	61	29.837			42	27	28		0.02	Clear
"	19th	"	30.306	76.98	65	30.207			36	16	27		0.0	Clear
"	20th	"	30.602	77.73	67°	30.497			36	15	27		0.0	Clear
"	21st	"	30.220	76.76	69°	30.115			36	25	35		0.0	Overcast
"	22nd	"	30.364	77.15	62°	30.284			39	13	13		0.0	Clear
"	23rd	"	30.676	77.92	59°	30.595			30	0	15		0.00	Clear
"	24th	"	30.322	77.03	60°	30.238			31	14	22		0.01	Clear
"	25th	"	30.702		62°	30.614			39	12	28		0.01	Clear
"	26th	"	30.476	77.40	68°	30.366			34	26	34		0.19	Snow
"	27th	"	30.386	77.19	69°	30.395			39	34	39		0.18	Overcast
"	28th	"	30.370	77.17	71	30.261			45	26	40		0.	Clear
Mar	1st													

Meter Experiments contd:—

The resistance of the bottles observed with 1 mamp just before removing the bottles was

1/12	1·055	3/14	0·950	5/16	0·920	7/18	0·900	Mean 0·955
9/10	1·750	11/12	2·150	13/14	2·050	15/16	2·050	Mean 2·00

These readings are respectively 22 % and 26·5 % less than the averages res: by weight.

The resistance of the solution at the temperature of 7° + 26° should be

$38 + 0{\cdot}0088 \times 43 - 0{\cdot}9313 \times 7 = 38 + 0{\cdot}38 - 0{\cdot}65 = 37{\cdot}73$ ratio 1·915

$38 + 0{\cdot}0088 \times 676 - 0{\cdot}9313 \times 26 = 38 + 5{\cdot}95 - 24{\cdot}22 = 19{\cdot}73$ or 52·2 % less

The ratio between the averaged res. is 2·205 or 45·4 %.

January 7th Monday

Took the sp. g. of different plates of cast zinc as follows:—

No. of plate	Valley	Quality	Weight in air	Weight in water	Difference	Sp. g.	Observer
1	1	Small cast	88·50	76·13	12·37	7·15	Lehmann
2	2	- -	102·25	88·09	14·15	7·22	
3	3	- -	94·95	81·80	13·15	7·22	
4	4	- -	105·00	90·46	14·54	7·225	
5	5	- -	99·68	85·92	13·76	7·250	
6	5	Cast metal pile	103·82	89·62	14·20	7·31	

On the cost of power
required for the electrodeposition of pure copper
from pure copper sulphate solution.

The ampere will deposit 1·18 grammes of copper per hour or $\frac{1}{384}$ lb.

Taking the sp. res: of solution at 50°, the distance between the plates at $\frac{1}{2}$" = 1·25 cms, then the resistance will be $\frac{75}{S}$ where S is the surface in sq. cms. If S be the square metre the conductivity becomes 133 mhos and the current is 133E per sq. metre E being the bank P.D. Taking E at 1·8 the current would be 133 ampere per sq. meter. Suppose that through polarization and other causes the actual current at unit P.D. would be 60 amperes, then the deposition of 1 lb. would take 6 hours per sq. meter, and 133 Watts or 799 = say 800 Watt hours per lbof metal. that is $1\frac{1}{10}$ HP hour per lb:

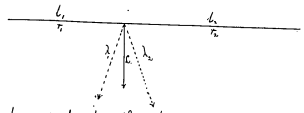
On the cost of power in the Laboratory).

Coal @ \$3·25 per ton = 3·25/2240 = 0·145 cts per lb.
5·25 lbs per HP. hour = 0·762 " per HP hour.
@ 120 volts the ampere = 1/746 HP. or 1 ampere Hour = 0·152

Water @ 18 cent per 1000-gallons = 0·018 cts per gall;
" 50 lbs per HP hr = 1·25 galls = 1·5 galls per amp hr. 0·027

0·179

The conditions under which the fall of potential on a given section may be a minimum.



Let l_1 and l_2 be the two portions of the section in feet
r_1 - r_2 - - resistances in ohms per foot of the conds.
$\mathcal{L}$ be the res: of the N.R.F.
λ_1 and λ_2 be the resistances of the corresponding portions of NRF
also let $r_1 = nr_2$

Then $\lambda_1 = \mathcal{L}\left(1 + \frac{l_1 r_1}{l_2 r_2}\right)$ and $\lambda_2 = \mathcal{L}\left(1 + \frac{l_2 r_2}{l_1 r_1}\right)$

$\sigma_1 = K \frac{c_1}{c_1+c_2}$ $\quad \sigma_2 = K \frac{c_2}{c_1+c_2}$

The fall of potential will be $\dfrac{E\, l_1 l_2 r_1 r_2}{l_1 l_2 r_1 r_2 + \mathcal{L} l_1 r_1 + \mathcal{L} l_2 r_2}$

$$= \frac{E\, l_1 l_2 n r_2}{l_1 l_2 n r_2 + \mathcal{L} l_1 n + \mathcal{L} l_2}$$

For a minimum we have $\frac{dD}{dn} = 0$

$$\pi \quad \frac{E\, l_1 l_2 r_2 (l_1 l_2 n r_2 + \mathcal{L} l_1 n + \mathcal{L} l_2) - E\, l_1 l_2 n r_2 (l_1 l_2 r_2 + \mathcal{L} l_1)}{(l_1 l_2 n r_2 + \mathcal{L} l_1 n + \mathcal{L} l_2)^2} = 0$$

or $l_1 l_2 n r_2 + \mathcal{L} l_1 n + \mathcal{L} l_2 = l_1 l_2 n r_2 + \mathcal{L} l_1 n$ $\quad$ or $n = \infty$

The fall of potential is always $\quad E \times \dfrac{1}{1 + \mathcal{L}\left(\frac{l_1 r_1 + l_2 r_2}{l_1 r_1 l_2 r_2}\right)}$

calling $l_1 r_1$ R_1 and $l_2 r_2$ R_2

this becomes $\quad E \times \dfrac{1}{1 + \mathcal{L}\left(\frac{R_1 + R_2}{R_1 R_2}\right)}$

and if c_1 and c_2 be the respective conductivities in mhos $\quad E \times \dfrac{1}{1 + \mathcal{L}(c_1 + c_2)}$

If $\mathcal{L} = \frac{1}{K}$ $\quad = E \times \dfrac{K}{K + c_1 + c_2}$

Similarly the fall in the NRF $= \quad E \times \dfrac{c_1 + c_2}{K + c_1 + c_2}$

From the above if a section of length $\mathcal{L}$ (feet) have a total number N of lamps at distances l_1 and l_2 from the termini to the center of distribution the number n_1 of lamps fed from the side l_1 will be $N\left(\frac{l_1}{\mathcal{L}}\right)$ and from the side $l_2 = \left(N \times \frac{l_2}{\mathcal{L}}\right)$

Multipolar Dynamo Characteristic Data

January 16th Wednesday.

Took the characteristic curve measurements of the Octopolar Dynamo after having approximately balanced its magnetism.

Time	Revs. per min.	Volts on Magnets	Amperes thru magnets	Amperes per coil of field	Voltage indicated	Reduced to 800 revs.	
15·35	815	–	3·4	0·85	28		
			3·6	0·9	29		
			3·8	0·95	30		
			4·0	1·00	33		
		20	4·5	1·13	36		
		22	5·4	1·35	42		
		24	6·8	1·7	54		
		30	7·5	1·88	62		
		34	9·0	2·13	70		
		40	11·0	2·75	81		
		49	13·0	3·25	88		
		55	14·5	3·63	95		
		58	15	3·75	97		
		64	16·5	4·13	103		
		67	17	4·25	105		
		69	19	4·75	108		
		74	20	5·00	114		
		83	22·5	5·63	119		
		90	24	6·00	124		
		94	25	6·25	125		
	825	108	29·5	7·38	132		
		–	30	7·50	135		
			31	7·75	137·5		
			32	8·0	139·5		
			33	8·25	143		
			34·5	8·63	144		
			35·5	8·88	145		
			36	9·00	146		
			37·0	9·25	149		
			38·0	9·5	151		
			38·5	9·63	152		
			39·5	9·88	153		
			40·0	10·0	153		
			41·5	10·38	154·5		
			43·0	10·75	156·5		

Transformer trial January 23rd after its repair.

Voltage on primary terminals 960
Amperes in primary circuit 7·5 Watts in primary circuit 7200

Voltage on secondary terminals 104
Amperes in secondary circuit 51·5 Watts in secondary circuit 5170
101 Lamps sustained.

When running without load current in primary cct 2·5 Watts 1920

Fields excited separately. Speed not known.
Res. of secondary 0·17 Loss in Watts 150·88 in Volts 8·75
- - primary 4·7 - - 264·35 35

Of the 7200 Watts absorbed 7165 were received magnetically
of the 5258 - - circuit 5170 - yielded externally

Total efficiency 72% electrical efficiency 73·4

Meter Tests.
January 24th Monday.

Following comparison made between a special meter of the Standardizing Bureau and our two standards. This special meter was designed to have a constant of 4 and of 8 on its two sides respectively. Passed the 35 ampere current in the lamp test room through it in series with the two standards in multiple. The solution used had been boiled afresh by Lehmann (it acidity) was 5–10 drops. The density was 1·0554 and it contained no appreciable amount of impurity. The zincs were all of plane, rolled material previously used but amalgamated hot. It was subsequently found that some of this amalgam of a thick pasty consistency had remained in the holes in spite of the ordinary precautions and the error of loss was perhaps due to the fact that some of this amalgam was found on the connecting screws:

No. of plate	Weight in grs. removed	Sum	Joint weight removed 21.1.29	Placed in Meter	Weight - grs. adding 24.1.29	Sum	Joint weight obtained 23.1.29	Gain	Loss
1	81·4469	159·7043	159·7053	A. Whit meter left hand side	· 81·5520	159·6745	159·6755	0·1055	
2	78·2575				· 78·1225				0·1350
3	83·5516	167·8003	167·8010	0·99 10 Sh.	Pt·1113	167·7975	167·7385	0·5597	
4	84·2487				· 83·6262				0·5225
5	82·3478	169·0889	169·0895	0·9954 Sh.	· 82·8577	168·9935	168·9920	0·5093	
6	86·7411				· 86·1358				0·6053
7	83·9715	169·5215	167·5220	B. Whit meter Right hand side	Pt·1782	167·4732	167·4735	0·2067	
8	83·5500				· 83·2950				0·2550

The test extended over 48 hours out of which the current was supplied for 35. The mean current was about 32 amperes making up a rough estimate of 1120 ampere hours. The bottles were removed and the plates dried and weighed. Something had commenced on the plates in the standard meters

No. of plate	Rough Lots.	Loss cold for meter error	Ampere-hours	Total ampere-hours	Ampere hour assuming meter 4.29	Ampere-hours assuming the meter one	Mean of loss + gain	Corresponding constants
1								
2	0·0298				1080	7·46	0·1253	1002·4 8·036
3	0·0625							
4		0·6238	509·7	1007·0				
5	0·0969							
6		0·6087	497·3					
7	0·0480				1020	3·95	0·2309	·923·6 4·36
8								

Owing to the existence of this discrepancy the plates were reamalgamated hot and the test repeated.

Comparison of the resistance of a platinoid strip with legal standard.

Jany 23rd 89

Connected the 0·1 ω Bergmann standard, the strip fastened round a table and a resistance box with a storage cell, and took following deflections beat with a f.s. of 300 divs (Taken as 290 for scale error) to the left.

No. of Obs.	Deflection on strip (full)	Deflection on 0·1ω (full)	Res. of 0·1ω @ 18·3°C	Difference (strip − ω)	ω	ω²	$\sqrt{\frac{\Sigma\omega^2}{n(n-1)}}$	Value of strip @ 18·3	Temp. at which strip carried	
1	571·9	569·4	0·09998	+ 2·5	+ 0·08	0·0064	0·02×0·09 = 0·0074	0·09991 × 572·6/572	−2·3°C	
2	571·0	568·6		+ 2·4	+ 0·18	0·0324				
3	570·0	567·6		+ 2·4	+ 0·19	0·0324				
4	569·1	566·8		+ 2·3	+ 0·28	0·0784		Diff = 2·58 ± 0·07	0·10043 ± 0·00001	
5	561·7 ~~1~~	562·0		+ 2·7	− 0·12	0·0144				
6	581·7	579·4		+ 2·3	+ 0·28	0·0784				
7	582·6	579·4		+ 3·2	− 0·62	0·3844				
8	582·5	579·7		+ 2·8	− 0·22	0·0484				
~ Scale error				Mean 2·58		Σω² 0·6752				

Repeated test Jany 25th with greater care. as follows — Temp. 0·1ω in bath 108° air 13·3 f.s. 300 taken at 320.

No. of Obs.	Deflection on strip (full)	Deflection on 0·1ω (full)	Res. of 0·1ω @ 13°C	Difference (strip − ω)	ω	ω²	$0.47143\sqrt{\frac{\Sigma\omega^2}{5\times4}}$	Value of strip @ 18·3	Temp. at which strip carried	
1	627·5	626·5	0·09992	+ 1·0	0·5	0·25	0·15081×1·05 = 0·16	0·09992 × 630/630	17°C.	
2	629·0	628·5		+ 0·5	0·0					
3	630·6	629·5		+ 1·1	0·6	0·36				
	Battery renewed						Diff = 0·53 ± 0·16	0·09991 ± 0·00024		
4	626·2	627·0								
5	628·0	628·6		+ 0·1	0·5	0·25				
6	629·1			− 0·05	0·5	0·25				
				Mean 0·53 +		Σω² = 1·11				

Joined up this strip in cct. with the 1000 Amp. large platinoid shunt the two triple strips of a large 700ω light Bergmann meter and the 5 volt Mains with the 40 Ampère meter in cct.

The 0·1ω strip was shunted by 1000ω and of this 1000ω the P.D. at 17 was led off to the galvanometer.

First comparison full 1000 Amp. shunt in series.

f.s. 320 taken at 310

No. of Obs.	Deflection on 0·1ω shunted	Deflection on 1000 Amp. shunt	Res. of strip at 18·7°C	Difference 0·1 − strip	Ratio for shunt	0·9503×0·09995	0·09495 × 1000/1000	Res. of shunt @ 16°C.	
1	655	623	0·09995	32	1·052				
2	655	623		32	minority				
3	657 zero rest	624		33	0·9503	0·09498	~~0·0949~~ 1·615	0·0001615ω	
4	650	617		33					
5	654								
	654·3	624·8		Mean 32·5					

General plan of strip

0·050009	0·02497	0·02241	0·01244	0·00620
		0·02485	0·01244	0·00620
	0·04992			

Total res: 0·09991 = @ 13·3°C.

Subdivision of strip
January 25th omitted:-

No. of Obs.	Deflin on entire ½ strip	Deflin on subdivided ½	Differences	Mean Diff	Ratio	Value of strip @ 13·3°	Value of entire ½	Value of subdivided ½		
1	669·7	662·8	6·9							
2	671·0	663·5	7·5 } 7·3							
3	671·8	664·3	7·5							
4	672·7									
	Probent current									
		663·9		3·5	666·5 / 663·	0·09991	0·050056	0·04992		
5	664·2	664·5	−0·3 } −0·2							
6	665·0	665·0	0·0							
	Reversed current									
7	667	660	7·0 } 7·0							
8	668	661	7·0							
9	668·6									

Corresponding test of ¼ lengths

No. of Obs.	Deflin on entire ½ strip	Deflin on subdivided ¼	Differences	Mean Differences	Ratio	Value of ½ strip	Value of entire ¼	Value of subdivided ¼		
1	681·8	682·5	−0·7							
2	682·3	683·0	−0·7							
3	683·0									
	Battery	reversed		+ 3·2	683·2 / 680·	0·04982	0·02497	0·02485		
4	683·5	677	6·5							
5	685·5	678	7·5							
6	686·5									
	Reversed current									
7	681·1	682·6								
8	682·6	682·1	−0·5							
		683·0	−0·6							

Corresponding test of ⅛ lengths.

No. of Obs.	Deflin on entire ¼ strip	Deflin on subdivided ⅛	Differences	Mean Differences	Ratio	Value of ¼ strip	Value of entire ⅛	Value of subdivided ⅛		
1		500·5								
2	499·5	501·6	−2·1							
3	500	502·5	−2·5							
	Battery	reversed		−1·0	501 / 500	0·02485	0·01244	0·012441		
4	502·8	502·5	+0·3							
5	493·5	493·0	+0·5							
		493·5								

Corresponding test of 1/16 lengths.. also of 1/32

No. of Obs.	Deflin on entire ⅛ strip	Deflin on subdivided 1/16	Differences	Mean Differences	Ratio	Value of ⅛ strip	Value of entire 1/16	Value of subdivided 1/16		
1	·	550								
2	552	550·6	1·4							
3	552·8	551	1·8							
	Battery	reversed		2·6	552·1 / 550·5	0·01244	0·00621	0·00620		
4		556·5								
5	560·5	557·5	3·0							
6	561·5	557·5	4·0							
1		286·3								
2	288·5	287·4	1·1							
3	288·8	287·9	0·9	3·6	289·6 / 288·	0·00620	0·00312	0·00308		
4	288·5	279·0	6·5							
5	288·0	279·0	6·0							

Special Meter test. (continued from page 75)

The trial was repeated with the same zinc reamalgamated hot, the holes carefully cleaned and the rods rewamished. The solution the same quality as that last employed except that it was rendered alkaline by the addition of zinc hydrate until a permanent opacity was obtained. It was then filtered and poured into the bottles. On this occasion smutting was noticed in both the standard meters. The zinc all became hydrated.

Meter Nos.	Weight obtained during 24.1.89	Sum.	Joint weight obtained 24.1.89	Read in meter	Weight obtained during 24.1.89	Sum	Joint weight obtained 24.1.89	Gain	Loss.
1 2	83·4645 81·8693	165·3338	165·3345	0·09980522	84·0060 81·3458	165·3518	165·3530	0·5415 (0·5330)	0·5235
3 4	83·4221 81·3882	164·8103	164·8115	0·09945522	83·9639 80·8733	164·8372	164·8380	0·5418 (0·5344)	0·5149
5 6	86·0362 84·1933	170·2295	170·2305	A	86·1549 84·0937	170·2486	170·2495	0·1187 (0·1193)	0·0996
7 8	83·0980 77·6664	160·7644	160·7647	B. (Trold Meter)	82·8915 77·8945	160·7860	160·7865	0·2281 (0·2297)	0·2065

The test commenced at 13.0 24.1.89 and ended at 12.0. 26.1.89 the current being about 30 amperes on the 130 volt cct. in the lamp test room, and the temp. about 23.5°C.

Meter Nos.	Sample Gain	Loss with gain for meter	Ampere hrs	Total Amp hrs	Amp hrs by constants of 44	Constants from 88 meter	Mean of Loss & Gain 2 obs	Similar Constants.	Mean Constants
1 2	0·0185	0·5245	428·5	~~851·6~~			0·5336	436·0 870·1	
3 4	0·0265	0·5378	422·1				0·5313	434·1	
5 6	0·0190			~~796·8~~	796·8	8·55	0·1092	874	7·97
7 8	0·0221			~~826·0~~	826·0	4·13	0·2173	869	~~4·095~~

Made a third test on the 28th (Jany) as follows:–

Meter Nos.	Sample gain	Loss with for meter	Ampere hrs	Total ampere hrs	Amp hrs by constants 44 & 45	Constants from 88 meter	Mean loss & gain	Similar constants.	
1 2	−0·0063			1160×8 928			0·1389	1289×8 ~~1181~~ 1107	7·64
3 4									
5 6	−0·0025	0·6570	537·9	1081·4			0·6592 0·6587 (1·2978)	1061 ~~881~~	
7 8	+0·0542	0·6651	543·5						

Test of Copy (maker of standard 0·1 legal ohm.
January 28th

No of Obs.	Deflcn on Copy	Deflcn on Standard	Difference	Temp Std	Temp Copy	Mean Diff.	Value of Std @ Temp	Value of Copy @ temp	Mean	Temp. at which Copy correct
1		675·2		°C	°C					
2	676·5	675·2	1·3	14·4°	14·8°	1·4	0·09986	0·10007		
3	676·5	675·3	1·2							
4	676·6	674·9	1·7							
5	676·8	674·5	1·3							
6	676·5									
7	672·5	670·8	1·7	14·4°	15·2°	1·8	0·09986	0·10014		
8	673·2	671·2	2·0							
9	673·8	Batt. reversed								
10	673·3	672·0	1·3	14·6°	15·4°	1·8	0·09987	0·10015		
11	670·4	668·2	2·2							
12	670·0									
13		658·8	1·2							
14	659·5	659·5	0·0			0·0				
15	659·5	659·5	0·0	15°	15°		0·09988	0·09988	0·09988 @ 15°C	21°C.
16	659·5	Batt: reversed								
17	659·2	660·6	−1·4			−1·4		0·09960		
18	659·8									
19	661·2	658·1	3·1	15·4°	15·6°	1·6	0·09990	0·10018		
20	661·5	658·5	3·0							

Repetition of test on 7th February

No of Obs.	Time	Deflection on Copy	Deflection on Legal ohm	Temp Std	Temp Copy	Difference	Mean Diff.	Value of Std @ 16·6°C	Value of copy @ 17·2°C	Temp. at which
1	16.46	671·5	673·8	16·6°C	17·2°C	+2·8				
2	16.48	672·0	673·6			+1·9	1·9	0·09993	0·10022	7°C.
3	16.50	671·5								
	Battery + galvo. reversed zero set									
4	16·52	670·5	671·8			+1·8				
5	16.54	669·6								

An analysis of the conditions of running in a motor.

Let E be the P.D. at the motor terminals.
" a - - res: of the armature
" l - - length of wire on its periphery traversing lines of force.
" v - - circumferential velocity of this wire.
" z - - average strength of magnetic field
" c - - current in the armature.
" e - - counter emf of the armature.
" τ - - torque
" f - - friction
" w - - work per second or activity

1st suppose the field magnets to be separately excited.

Then the current is $\dfrac{E-e}{a} = \dfrac{E - lvz}{a}$

the pull tangentially is $= lz\left(\dfrac{E - lvz}{a}\right)$

Under all conditions of activity, w must not vary widely and in the activity $w = lvz\left(\dfrac{E - lvz}{a}\right)$ z is the only variable.

$$\frac{dw}{dz} = lv\left(\frac{E - lvz}{a}\right) - \frac{lv}{a} \times lvz$$

$$= \frac{lv}{a}(E - 2lvz)$$

$\therefore$ if $e < \dfrac{E}{2}$ w increases by increasing z

" $e > \dfrac{E}{2}$ w diminishes " " "

So that when the efficiency is over 50% the activity is increased by weakening the field, and when the efficiency is under 50% the activity is increased by strengthening the field.

The commercial efficiency of a motor (series or shunt wound) is

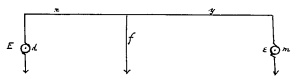
$$\eta = \frac{e}{E}\,\frac{\dfrac{E-e}{a} - \gamma}{\dfrac{E-e}{a}}$$ where γ is the minimum current that will run the motor up to speed unloaded.

Hence the maximum value of η is under the condition

$$(E-e)c = E\gamma$$

or the energy expended as heat in the armature at work must equal the total energy expended on running the motor light. This equation also takes the form

$$(E-e) = \sqrt{Ea\gamma}$$



If d be the res: of the dynamo armature E its internal emf, m the res: of the motor, e its internal e.m.f x and y the resistances of the intervening line up to the N.R.F of res: f. Then

$$C_x = \frac{E(f+y+m) - ef}{(x+d)(f+y+m) + f(y+m)}$$

$$C_y = \frac{Ef - e(f+x+d)}{(x+d)(f+y+m) + f(y+m)}$$

$$C_f = \frac{E(y+m) + e(x+d)}{(x+d)(f+y+m) + f(y+m)}$$

Test of a 700 Light meter made by Bergmann -B:

Placed this meter in the 100 ampere lamp-test circuit in series with the carpenter's shuntstrip 0·1 strip divided into 2 branches ~~[illegible]~~ and having thus a resistance of approximately 0·025ω. The terminals of this 0·025ω were led to two separate 25 ft bottles through 295' [illegible] so that a double meter was thus formed. The temp: of this strip commenced at noon on the 23rd [illegible] reached about 55°C. The test lasted a period of 6 days and some 88 hours of current. and ended at noon on the 4th

Read Plate	Weight empty 24.1.09	Weight empty 4.2.09	Gain	Loss	Mean Loss	Amp. Hrs.	Ratio			
1	352·7085	351·2211		2·5674						
2	350·2565	352·9562	2·4997							
3	354·9307	356·5257	2·4950							
4	353·0815	350·5242		2·5573						
5	352·2905	334·8571	2·5576							
6	352·8822	349·9970		2·6232	2·5743	2103×3 = 6309×29 = 6157	1·011			
7	352·5905	355·1016	2·5111							
8	350·1948	347·6380		2·5568						
9	329·5520	326·0229		2·5291						
10	331·2440	333·5132	2·4692							
11	349·7038	347·0916		2·6122						
12	353·0319	355·7216	2·6897							
13	86·6574	86·0246		0·6328						
14	86·0523	84·6470	0·5947		0·6319	6086				
15	83·5559	84·1415	0·5856							
16	76·6513	76·0203		0·6310						

The solution used was boiled 1.054 from ch. vom. sol: 5 strips used
The plates kept clean but were all smutted so that the gains are not reliable.
The following test was made of this strip shunt. 7th Febry. 09

Read No.	Time	Deflection on 4 Std ω	Deflection on Shunt	Difference	Mean Diff	Temp. Std 4	Ratio	Value of Std @ 4°C	Value of Strip @ 17°C.	Value @ 55°C.
1	16·51	660·9	660·8	0·						
2	16·53	659·8	660·7	+ 0·9						
3	16·54	659·0	659·9	+ 0·9						
	Batty: + galv: reversed zero not				0·7+	17°C.	$\frac{6607}{660}$	0·025ω	0·025ω	0·252ω
4	17·0	655·2	659·5	+4·3						
5	17·02	655·5	660·3	+ 4·8						
6	17·04	665·1	660·5	−4·6						
	Batty + galv: reversed zero not									
	17·08	656·7	655·5	−1·2						

$\frac{0.0252}{297} = 0.848 \times 10^{-4}$ so that proportion of current in bottle $= \frac{1}{1.179 \times 10^4}$

$\frac{0.6319 \times 1.179 \times 10^4}{1.2224} = 6086$ ampere hours.

Agreement of mean values within 1·1%

1ω shunted by 1000ω = joint res. of 0.9991 ω

1ω " " galv. 550ω = 9.82ω joint res.

Multiplying power $\frac{999.82}{9.82} = 1018$

$\therefore$ true res. $= \frac{0.99993 \times 656.4}{1018 \times 655.0} = \frac{6.5595}{666680} = 0.0000982$

$= 0.0000 97985$ @ 0°C.

0.1ω shunted by 700ω = joint res. $\therefore$ 0.1ω

10ω " " 550 = 9.82ω joint res.

Multiplying power $\frac{999.92}{9.82} = 71.28$

$\therefore$ true res. $= \frac{0.09993 \times 340}{71.28 \times 335.3} = \frac{3397}{23985} = \frac{33.97}{2.39 \times 10^4} = 14.21 \times 10^{-4} = 0.0014$

Test of standard 0.01ω copied from legal ohm and made of platinoid strip soldered to copper rods.

No. of Obs.	Time	Deflection on legal ohm	Deflection on copy	Diff.	Mean Diff	Temp.	Value of std. @ temp	Value of copy	Temp. at which current	
1	15.26	658.2	659.5	+1.3						
2	.28	658.0	659.9	+1.9						
3	.31	658.0	660.0	+2.0						
	Batty. + galv. reversed.									
4	.34	655.7	657.8	+2.1						
5	.36	655.8	657.2	+1.4						
6	.39	655.0	656.1	+1.1				$\frac{656.4}{655} \times \frac{40}{100}$		
7	.40	654.3	658.0	+0.7						
8	.43	653.6	653.4	−0.2	1.44	16.5°C.	0.9998	0.9982×10^{-2}	about 108°C.	
9	.45		653.5	−0.5				$= 0.000982$		
10	.47	651.0								
11	.49		653.0	+3.0						
12	.50	650.0								
13	.51		651.8	+1.5						
14	.52	650.3								
15	.53		651.2	+2.0						
16	.54	649.2								

Test of the conductivity of a 10-foot copper rod ½" diam.:
The ends were bent at right angles and inserted in mercury cups. Wire connections were made near the ends and at a distance apart of 269 cms. The mean diameter was 0.25".

No. of Obs.	Time	Deflection on 0.1ω	Deflection on rod.	Diff.	Mean Diff	Value of 0.1ω	Value of rod @ Temp. of rod	Dimensions	Spec. resist. @ temp	% Conductivity
1	17.40	334.4	342	+5.6				$l = 269$		
2	.46	335.3	350.9	+5.6				$r = 0.3187$	1686 @ 17°C.	
3	.48	334.6	339.8	+5.2		0.0999Ω		$r^2 = .0101155$		
	Reversed Batty. + Galv. reversed				+4.7	17.9°C	0.001421	$r^4 = .031191$	1579 @ 0°C.	100%
4	.50	329.9	333.5	+3.6						
		329.4	333.5	+4.1						

Conductivity measurement of a ½" copper rod taken from the Stock Room 8th & 9th February.

Compared rod by deflection test with 0·1 Ag. Ohm by shunting latter with 700 ohm and taking 10 to the galv.

Diam. of rod 0·251" = 0·6373 cms. Length between knife edges 255·7 cms. This length @ 20·6° c. (min) just balanced the shunted legal ohm (21·2°c)

Length Rod	Area	Res. of 5ft @ temp	Multiplying Power	Res. of rod @ temp	sp. res. @ 20.6°C	sp. res @ 0°C.	Standard Conductivity	% Cond.			
255·7	0·3187	0·10008	7·28	0·0011403 = 1·1403×10⁻³	1749	1612	1584	98·3			

Compared with this rod a certain alloy bar of composition brass. Obtained from Messrs Bergmann & Co through Mr Wire.

Dimensions @ follows. Mean length between knife edges 44·7
" breadth of 7 measurements 2·058
" thickness " 1·239

Established deflection balance between 43·8 cms between knife edges of the rod. temp. 20·1°c.

Length Rod	Res. of this length	Length bar	Area	sp. res. @20°c	% Conductivity of brass alloy	% Conductivity of pure copper					
44·7	2·403×10⁻³	44·7	2·5446	1369×10⁻⁶	1722×10⁻⁶	12·6%					

A second test of this made on a previous date as a preliminary measurement and not so close a determination gave the equivalent length of copper rod above measured as 46·5 cms to 44·0 cms between knife edges on brass alloy bar — practically the same results.

Meter Test.

Took the weight of pair of Nickel plates that have been standing for a month on the shelf, with the view of finding the relative hydration gain.

Plate No	Date of preparation	Solution density	Quality of water	plates	Weight of Simply	Weight of Simply 6.2.89	Gain	Gain per Gram	Remark		
1	7.1.89	1.0514	Infusorio	amalgamated but not heated	124·7490	124·7548	0·0058	0·0219	All plates		
2					115·2500	115·2561	0·0061				
					239·9990	240·0109					
3	7.1.89	1.105	"	"	116·8850	116·8902	0·0052	0·0076			
4					116·0730	116·0754	0·0024		on backs		
					232·9580	232·9656			and rim		
5	7.1.89	1.152	"	"	114·4925	114·4859	−0·0066	−0·0030	cost 5% Hg		
6					115·8690	115·8726	+0·0036				
					230·3615	230·3585					
7	7.1.89	1.216	"	"	119·3860	119·3934	+0·0074	0·0130			
8					124·0170	124·0246	+0·0076				
					243·3330	243·3440					
1a	5.1.89	1.0514	"	"	111·2025	111·0750	−0·1275	−0·3188			
2a					120·1690	120·0947	−0·0743				
					231·3905	231·1717					

Measurements with Absolute Electrometer 16th Feby 89

Initial sighted position of disk screw when jar discharged 0·02114 mean of 6
After charging jar by means of influence machine 0·3 gr
corresponds to

	1·4327
Set position	1·40541

Earth reading of this charge 12·47 on micrometer screw
$= 12.47 \times 0.02 \times 2.54 = 0.634$ cm.

The potential corresponding to this is

$$0.634 \sqrt{\frac{8 \times 3.1416 \times 0.3 \times 980}{(2.2575)^2 \times 3.1416}} = 0.634 \sqrt{1347 \times 0.3}$$

$$= 0.634 \times 39.2 \times 0.550 = 12.67$$

$= 420$ volts.

Took the 113 volt circuit and grounded one side of it.

Earth Reading		Dynamo Reading	
12·43		1203	
12·48		1218	
1250		1213	
1240		1202	
1245		1211	
1252		1215	
1250		1216	Mean 1210
1248	Mean 1247		

Difference ·37

P.D ∴ $= 0.37 \times 0.0508 \times \frac{39.2 \times 0.550}{2.536} =$ ~~[illegible]~~ abs: st units 0·4053
$= 12.5$ volts.

Took the 1500 volt circuit and took the potential of each terminal

Earth Reading		Dynamo Reading	
1259		1481	
1267		1493	
1256		1479	
1259		1482	
1263	Mean 1260		Mean 1481

Difference 221

1257		1031	
1262		1024	
1251		1029	
1254	Mean 1256	1033	Mean 1029

Difference 2·27

	4·52

P.D ∴ $4.52 \times 0.0508 \times 24.56 = 4.958$ abs: e. units
14·85 by 1490 volts.

Repeated measurement with 0·1 gramme force on disk follows:-

Initial position	0·02114
0·2 gramme	0·96943
Set disk screw at	0·99057

	Earth reading		Dynamo reading	
Right hand	1807		1489	
	1822		1501	
	1807		1505	
	1791		1490	
	1812	Mean 1809 Difference 319	1484	Mean 1490

Left hand	1805		2110	
	1786		2118	
	1799		2103	
	1795		2113	
	1796	Mean 1796 Difference 316	2114	Mean 2112
				622

PD $6.22 \times 0.0508 \times 39.2 \times 0.447 = 5.538$ abs: e. units
$= 1660$ volts.

Computations 21st March 1911

$t = \frac{R_c C}{R} \log_e \frac{V_0}{V_t} \times 2.3026$

$\frac{4}{3}\pi r^3 \sigma = 28.7$ gms. If $\sigma = 7.8$

$\frac{4}{3} \times 3.142 \times 7.8 \times r^3 = 28.7$ $\quad r^3 = \frac{3 \times 28.7}{4 \times 24.52} = \frac{28.7 \times 3}{98.08} = 0.2926 \times 3 \quad r^3 = 0.8778$

$r = 0.9575$ cm. $\quad d = 1.9150$ cm $= 0.754''$

Assuming the diameter at just $0.75''$ = 1.905 cm. $\quad r = 0.9525$ cm.

$r^3 = 0.86416, \quad \sigma = \frac{28.7 \times 3}{4\pi\, r^3} = \frac{86.1}{12.566 \times 0.86416} = \frac{86.1}{10.859} = 7.928$

Assuming $T \propto t$, we have in the series at the foot of the next page:-

Trial No	Drop Inches	Drop cms.	Full Deflection	Deflection after disp	$\frac{V}{V_0}$	$\log_e \frac{V}{V_0}$	Time sec.	Mean Time	Mean $\frac{T}{L}$	$\frac{T}{L}$
1	14.563	36.99	251	203	1.2364	0.212150	1.9×10^{-4}	300	56.53	56.53 29.52
3	10.0	25.4	278	220	1.2636	0.101622	1.0	"	69.26	69.26 36.17
4	6.0	15.24	278	222	1.2522	0.09769	-	-	66.57	66.29 34.62
5	"	-	278	198	1.5618	0.19362	-	-	80.00	80.00
6	-	-	278	219	1.2692	0.10353	-	-	70.57	70.57 36.85
7	2.0	5.08	278	219	1.2692	0.10353	-	-	70.57	

Sink and mercury

Resistance of 5th Table astatic Galvanometer with all four coils in multiple arc.

Temp Bridge	Bridge	Reading	Lead	Res.	Temp. the coil in temp	Temp. Galvo	Res. at 0°C calculated	Date
18.7°	1000/100 1Ω Lab.	485.2	0.38	484.82	484.9	18.2°	452.25	16.2.89

20th February Wednesday

Sent down to the Phonograph Factory in accordance with instructions 14 oz. of platinoid wire No. 26 B.W.G. 0.018" having a res. of 16 % to the ohm.

21st February Thursday.

Took one of the Bergmann 100,000 ω boxes apart and as they were in B.A. ohms and 1 % short for usual requirement added to each about some 75 feet of no. 35 BWG 0.005" wire G.S. silk covered having a res. of 5.7 ω per foot.

After completion the box tested as follows:

Coil No	Obtd res	Coil to Temp Bridge	Bridge etc.	Temp at which coil correct.	Temp. of box obtd.	Total Res. @ 19.5°	Total Res. @20°C.	
1	25020	25010	100/1000 20°C.	18.5°C	19.5°C.	99945 ω	99965 ω	
2	24981	24970		23.5°				
3	24998	24990		20.5°				
4	24985	24975		22°C.				

Made a series of measurements of the coefficient of self induction in some coils by Rimington & Arkemp method. From these it would seem that the coefficient of load for the 0.04 decomutator is 0.03. The Ratio of the handle and commutator angular velocities is 2.143 ($\frac{4}{7}$) and 6 respectively for the low and high speed.

22nd February Friday

Took a series of measurements of the time of impact between a falling sphere and an anvil as follows:-

The anvil had it upper hardened surface channel and was tilted in such a manner as to throw the ball from it after first impact.

The first ball was of steel its diameter was 0.75" and its weight 28.7 grammes.

Trial No	Drop Inches	Drop Cms.	Full Deflect	Deflect after disp	$\log \frac{V}{V_0}$	Bounces	Duration of impact	Res in set	
1	14 3/4	36.9	251	205 / 201 } 203	0.0217	0.9	5.7×10^{-5}	0.0003 ω	
2	-	-	.						
3	10"	25.4	278	220 / 220 } 220	0.10162	1.0	7.0×10^{-5}	"	
4	"	"	"				6.8×10^{-5}		
5	6"	15.24	278	235 / 178 } 198	0.0977 / 0.19362	"	13.0×10^{-5}	"	Full Curve on mirror. No double jerk
6	"	"		219 } 219					
7	2"	5.08	278	218 / 220 } 219	0.10360	"	7.1×10^{-5}	"	

From this series it would appear that the duration is independent of the height.

Impact Experiments, contd:

t	No.	Metal	Diam.	Mass.	Drop.	Full deal.	Rest after deal.	log ξ	Coefficient φ	Res. Ω	Tuning frequency	Mean	Gen. mean
37.79	1	Steel	1" = 2.54cm	67.01g.	2" = 5cm.	27½	19.8	0.1143	1†	0.0003	9.88×10^{-2}	9.6	
	2					27.5	18.8	0.249	1†	0.00015	9.3×10^{-2}		
30.45	3		3⅜ = 9.7		3⅜ = 9.7	-	15.2	0.257	"	"	8.9	8.75	
	4				" "		15.5	0.249	"	"	8.6		
33.07	5				6¾ = 17.3		15.6	0.246	"	"	8.5	8.14	8.8
	6				" "		15.8	0.241	"	"	8.3		
31.89	7				10 25.4		15.7	0.243	"	"	8.4	8.1	
	8				" "		16.3	0.227	-	-	7.8		
36.41	9				2" 5.1		14.5	0.278	"	-	9.6	9.3	
	10				" "		15.1	0.260	-	"	9.0		
38.58	11		½" 1.27	7.8	2" = 5.1	27½	19.8	0.1143	1†	0.00015	4.9×10^{-2}	4.9	
	12				" "	-	19.8	0.1143	-	-	4.9		
34.46	13				3⅜ = 9.7		20.5	0.1128	-	-	4.4	4.4	
30.71	14				10" = 25.4		21.2	0.113	-	-	3.9	3.9	
40.25	15		½" = 0.635	1.3 g.	3" = 7.6	27½	23.15	0.073	1†	0.00015	2.5×10^{-2}	2.55	
	16						23.1	0.074			2.6		
33.07	17				6" = 15.2	*	22.2	0.091		0.0001	2.1×10^{-2}	2.1	
	18						22.2	0.091			2.1		
31.49	19				10" 25.4		22.5	0.086		0.0001	2.0×10^{-2}	2.0	
	20						22.5	0.086			2.0×10^{-2}		
47.24	21	Copper	1" = 2.54	75g	2" = 5.1	27½	8.5	0.508	1†	0.0001	11.7×10^{-2}	12.0	
	22				" "		8.0	0.538			12.3		
41.73	23				6" = 15.2		9.6	0.465			10.5	10.6	
	24				" "		9.8	0.469			10.8		
	25				" "		9.6	0.455			10.5		11.1
41.73	26				10" = 25.4		9.3	0.469			10.8	10.6	
	27				" "		10.0	0.438			10.1		
	28				" "		9.3	0.469			10.8		
42.0	29		⅜" = 1.9	31.7	2" = 5.1		12.0	0.339			7.8	8.0	
	30				" "		12.2	0.351			8.1		
40.41	31				6" = 15.2		12.7	0.334			7.7	7.7	
	32				" "		12.8	0.331			7.6		
38.85	33				10" = 25.4		12.6	0.337			7.8	7.4	
	34				" "		13.6	0.304			7.0		
	35				" "		13.2	0.317			7.3		

* Reversed small wire to observe whether any contact e.m.f. between the copper and steel at point of contact introduced any effect.

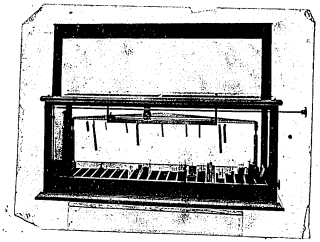
Impact Experiments contd:

No. of Fall	Metal of Plate	Diam.	Mass	Drop	Fall in inch	Per Capacity	Recovery Rebound	Eng. ft	Time	
1	Copper	$\frac{1}{2}$" = 1.27	9. grams	2" = 5.1	274	0.00014 ft	151	1.259	5.97×10^{-5}	5.8×10^{-5}
2				2" = 5.1		0.00014 ft	157	0.2241	5.6×10^{-5}	
3				2" = 5.1		0.00001 ft	10	1.246	23.46×10^{-5}	
4				2" = 5.1		0.00001 "	8	1.574	0.38×10^{-5}	
5				6" = 15.2		0.00001 "	6	1.460	0.38×10^{-5}	
6				6" = 15.2		0.00010 "	94	0.125	5.3×10^{-5}	
7				6" = 15.2		0.00015 "	166	0.215	5.0×10^{-5}	5.3×10^{-5}
8				6" = 15.2		0.00015 "	189	0.161	7.8×10^{-5}	
9				6" = 15.2		0.00020 "	212	0.111	5.1×10^{-5}	
10				10" = 25.4		0.00001 "	58	0.714	?	
11				10" = 25.4		0.00001 "	0	∞		
12				10" = 25.4		0.00001 "	55	0.697	?	
13				10" = 25.4		0.00005 "	105	0.417	4.8×10^{-5}	4.9×10^{-5}
14				10" = 25.4		0.0001 "	168	0.212	4.9×10^{-5}	
15				10" = 25.4	274	0.00015 "	196	0.1145	5.0×10^{-5}	
1	Copper	$\frac{1}{2}$"	0.68	1.35 gr	274	1 ft 0.00015 a	222	0.091	3.2×10^{-5}	3.2×10^{-5}
2				2" = 5.1		0.0001	206	0.126	2.9×10^{-5}	
3				2" = 5.1		0.00005	141	0.288	3.3×10^{-5}	
4				6" = 15.2		0.00005	158	0.238	2.7×10^{-5}	2.9×10^{-5}
5				6" = 15.2		0.0001	206	0.123	2.8×10^{-5}	
6				6" = 15.2		0.00015	223	0.089	3.1×10^{-5}	
7				10" = 25.4		0.00015	231	0.073	2.5×10^{-5}	2.4×10^{-5}
8				10" = 25.4		0.00015	236	0.0644	2.2×10^{-5}	
9				10" = 25.4		0.0007	255	0.030	?	
10				10" = 25.4		0.00005	166	0.219	?	
11				10" = 25.4		0.00001	8		?	
1	Zinc	1" = 2.54	61.5 gr.	2" = 5.1	277	1 ft 0.00001	5			
2						0.00001	10			
3						0.0001	72	0.585	13.5×10^{-5}	13.9×10^{-5}
4						0.0002	135	0.312	14.4×10^{-5}	
5						0.0003	176	0.197	13.6×10^{-5}	
6				6" = 15.2		0.0003	186	0.143	9.9×10^{-5}	
7				(		0.0003	186	0.143	9.9×10^{-5}	9.7×10^{-5}
8						0.0002	152	0.160	7.4×10^{-5}	
9						0.0001	86	0.588	11.7×10^{-5}	
10				10" = 25.4		0.0001	81	0.534	12.3×10^{-5}	
11						0.00002	155	0.252	11.6×10^{-5}	12.2×10^{-5}
12						0.0003	189	0.166	11.8×10^{-5}	
13						0.00004	197.5	0.1146	13.4×10^{-5}	

Gen. Mean 11.9

Meteorological Record.

Date	Tenths	Barometer Reading In.	Barometer Reading Cms.	Temp of Barom.	Bar. red. to 32°	Max. Temp.	Min. Temp.	Thermometer Standing at Dry	Wet	Rainfall last 24 hrs.	Cloud	Wind	Weather & Rain
Mar 1st	Noon	30.378	77.17	71°	30.241	55°	26°	40°		0.18	Nimbus		Overcast
2nd	+ 14	30.242	76.81	72°	30.122	64°	29°	43°		0.	Nimbus	0	Overcast
3rd		30.010	76.23	70°	29.996	45	33	42		0.08	Nimbus	0.08	"
4th		29.636	75.28	63°	29.543	44	33	40		0.51	Nimbus	0	Rain
5th	+ 14	29.412	74.72	70°	29.298	44	37	44		0.50	Nimbus	N fresh	Rain
6th	+ 14	29.158	74.07	68°	29.050	47	33	44°		0.	Cirrus	N fresh	Clear + Tem
7th		29.820	75.77	71°	29.693	50	35	43°		0.	Cirrus	N fresh	Fine
8th	+ 14	29.406	74.69	71°	29.289	54	31	40		0	Cumulus	W. fresh	Fair
9th	+12	29.551	75.06	67°	29.443	42	30	35°		0	Cumulus	W. fresh	Overcast
10th		29.648	75.22	60°	29.560	38	30	37		0	Cirro cumul.	W.	"
11th	+ 12	29.820	75.73	66°	29.738	39	29	37		0	Clear	N	Fine
12th		29.910	75.97	73°	29.787	52	37	46		0	Clear	N	Fine
13th	+18	29.916	75.99	81°	29.769	62	29	56		0	Clear		Fine
14th	+22	30.220	76.78	70°	30.079	70	36	41		0	Clear		Fine
15th	+22	30.006	76.24	68°	29.898	57	32	40		0	Nimbus	E mod.	Overcast
16th		29.740	75.55	71	29.623	51	36	51		0.01	Cirro cumul.	E	Fair
17th		29.704	75.46	60	29.660	55	37	55		0.23	Nimbus		Overcast
18th		29.792	75.68	71	29.675					0.			
19th		29.736	75.54	70°	29.622	60°	35	47		0.	Nimbus		Overcast
20		29.662	75.35	71	29.565	75°	35°	71°		0.05			
21st		29.750	75.56	72°	29.630	40°	34°	39°		0.65	Cirrus		Fine
22nd		30.284	76.42	73°	29.961	46°	35°	46°		0.40	Cirrus	E	Fine
23rd		30.022	76.26	80°	29.978	70°	31°	52°		—	Clear	Light W.	Fine
24th		29.720	~~74.78~~	70°	29.706	77	39	77		—			
25th		29.520	74.98	70°	29.406	54	39	52		—			
26th		29.			29.652	64	41	64		—			
27th		29.904	75.95	76°	29.772	54	27	52		—			
28th		29.754	75.58	77°	29.619	63	29	40		0.1	Rain		
29th		29.930	76.03	73°	29.807	48°	27°	48		0.01			Fine
30th		30.240	76.81	71°	30.123	60	25	34		0.02	Clear	Fresh N.W.	Fine
31st		29.938	76.01	69°	29.857	52	26	36		0.15	Nimbus		Snow mixt.
Apr 1st		29.754	75.57	66°	29.602	42	35	42		0.05			Rain
2nd		29.616	75.25	71°	29.579	51	36	49		0.70			Overcast
3rd		29.808	75.69	75°	29.764	50	34	50		0.0			
4th		29.828	75.77	70°	29.714	68	39	50		0.0	Cumulus		Fine
5th		29.956	76.10	75°	29.827	53	29	49		0.0	Nimbus		Fair
6th		30.116	76.49	65°	30.015	63	32	47		0	Nimbus		
7th		30.222	76.78	52	29.162	48	33	33		0			
8th		30.050	76.32	66°	29.948	60	31	52		0			
9th		29.790	75.68	70	29.676	71	37	59		0	Clear	Light E.	Fine
10th		29.836	75.79	76°	29.704	67	46	58	47	0	Clear		Fine
11th		29.936	76.00	80°	29.792	73	31	63	50	0	Cloudy		
12th		29.866	75.80	67	29.401	77	53	60	57	0.08	Nimbus		Thunderstorm
13th		29.992	76.18	55	29.925	64	30	51	45	0.	Cirrus		Fine
14th		30.254	76.85	71	30.137	71	31	52	43	0	"		Fine
15th		30.230	76.83	73	30.127	62	35°	51	43	0			
16th		29.976	76.14	69°	29.868	58	41	52	50	0	Nimbus	N E strong	Rain
17th		29.906	75.96	71°	29.787	61	51	60	57	0.06			
18th		29.972	76.13	75°	29.843	80	47	76	61	0	Clear	"	Fine
19th		29.906	75.96	69°	29.822	92	52	70	64	0	Cloudy		
20th		29.708	75.46	66°	29.600	75	57	74	60	0.22	Cirrocum.	N fresh	Fine
21								62	42	0.			
22nd						67	30	60	51	0			
23rd						73	36	72	60	0			
24th								76	66	0			
25th		29.892	75.93	74°	29.766	81	47			0			
26th		29.604	75.2	65°	29.505	80	56	59	57	1.53			
27th		29.226	74.24	70°	29.112	61	55	56	55	2.69			
28		29.338	74.53	76°	29.206	56	56	58	53	0.19			
29th		29.450	74.80	66°	29.348	66	48	61	54	0.03			
30th		29.550	75.06	68°	29.442					0.10			



Main Calculator Determinations.

The following are the dimensions of the beam of aluminium.

Total length 66 mm (26").
Central Breadth 3.4 Breadth at extremities 1.0
Thickness 0.097" = 0.025. Thickness of upper thatch plate 0.022" = 0.06
Width of slit 0.3 Length 34.4
Width of thatch plate central 1.5 at extremities 1.00.
Weight of beam. 100 gms.
Safe experimental load 5000 gms.
Weight (experimentally) necessary at one end to balance beam when knife edge hard up 105 gms. 24 ozs for the thatch to the beam.

Specific gravity of a sample of sheet brass.
Strip Length 8.8 breadth 4.3 thickness 0.1475. Volume 17.97
Weight in air 144.8·36 gms. Density (mm vol.) 8.256.
Weight in Lab water @ 12.5°C 130.82 gms. Loss 17.54 sp g. 8.4856
Density of brass by table. Scovill Mfg. co. 8.22 anthony & Brackett 8.4.

From the map of the Brooklyn district it would seem that the greatest number of lamps (likely) to be between any two feeder points is 1000 and equating this to the safe load of the beam each light becomes 5 ~~with~~ grammes.

Beneath the beam there are 22 pockets 4 1/2" × 1" × 1 1/2" deep for weights

No. of lamps represented	~~Weight~~ Grams	Vol. c.c.	Vol. c.in.	Thickness of brass plate in.	Area Sq. in.	Breadth in	Length in.	Nearest simple fraction	No: in pocket	No. of weights
1	5	0.595	0.0363"	0.025"	0.290	0.5"	0.58"	9/16	38	3
2	10	1.190	0.073		0.581		1.16	1 1/16		4
3	15	1.785	0.119		0.870		1.74	1 3/4		5
4	20	2.380	0.145		1.162		2.32	2 5/16		5
5	25	2.975	0.182	0.25	0.726		1.45	1 7/16	18	5
6	30	3.570	0.218		0.871		1.74	1 3/4		5
7	35	4.166	0.254		1.016		2.03	2 1/4		5
8	40	4.760	0.290		1.162		2.32	2 5/16		5
9	45	5.355	0.327		1.307		2.85	2 7/8		5
10	50	5.951	0.363		1.452	1.0"	1.45	1 1/2		5
12	60	7.140	0.436		1.742		1.74	1 3/4		5
15	75	8.925	0.545		2.178		2.18	2 3/16		5
20	100	11.905	0.726		2.904		2.90	2 7/8		10
25	125	14.875	0.908	0.375	2.420		2.42	2 7/16	12	10
30	150	17.853	1.089		2.90		2.90	2 7/16		5
40	200	23.810	1.452		3.87		3.87	3 7/8		5
50	250	29.75	1.815		4.84	2.0"	2.42	2 7/16	4	5
60	300	35.70	2.178		5.81		2.91	2 7/16		2
70	350	41.66	2.541		6.78		3.39	3 3/8		2
80	400	47.60	2.904		7.75		3.88	3 7/8		2
90	450	53.65	3.267		8.71	2.5"	3.48	3 1/2	9	1
100	500	59.51	3.630		9.68		3.87	3 7/8		1
										100

Record of some experiments on the electrocide of animals made on the 12th March, for the New York State Commission.

Preliminary determination of Gardner Voltmeter Constant.

Angular Deflection	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
Volts	50	60	65	70	78	84	90	96	102	107.5	113	119.5
Corresponding Mean Alty Voltage	45	54	58.5	64	70	75.5	81	86	92	96.7	102	107.5

Res: of Gardner 465 Res: of wire in cct 2200 Multiplying power 14.33

1st A white half spitz dog weighing 21½ lbs: res: 2700 Ω.
Electrodes bandages of waste dipped in hot Zn SO4 sol. density 1.1
Voltage 100° Gardner = 92 × 8 = 736 Time 10 seconds
Dog protruded tongue during application of current but never moved when current off. No sound nor gasp, nor heart action.

2nd A black newfoundland dog Wt 8½ lbs: res 2200
Hair on forehead clipped felt electrodes 4" × 6½" soaked in Zn SO4 bid on forehead after thoroughly wetting skin. Bandage of waste on right hind leg above knee.
Voltage 110° Gardner = 96.7 × = 773.6 Time 15 seconds.
Dog rigid during application and never stirred afterwards.
No sounds gasps or heart action.

3rd Mongrel liver colored. weight 60 lbs. res. 1000 Ω.
Contact back of neck with ~~same~~ larger felt electrodes 9" × 12" and over heart under axilla with smaller electrode 4½" × 6".
Voltage 85 = 83 × 8 = 664 Time 10 second.
Dog made several gasps after removal of current and showed signs of recovery. Evidence of current passing over skin through wet hair owing to large electrode so wet and so close. Singeing of hair audible. Safety catch carried away.
Repeated voltage 70° = 75.5 × 8 = 604 Time 10 seconds.
Same singeing of hair between electrodes and safety catch nearly melted. Dog not quite dead.
Removal electrode from axilla to a bandage round ~~left~~ right hind leg above knee.
Voltage 80° = 81 × 8 = 648 Time 10"
Res: after death 250 Ω.

4th Brown small mongrel weight 35 lbs. res: 500 Ω.
Contact on forehead with small felt electrode and a waste bandage on the right hind leg above knee.
Res: 500 Ω.
Voltage 50° = 64 × 8 = 512 Time 10"
No sound gasp or heart action after removal of current.

5th Calf weighing 74 lbs: res: 500 Ω.
Electrode on right hind leg with wetted waste.
and smaller felt electrode on back of neck.
Voltage 90° = 86 × 8 = 688 Time 15".
Calf not quite dead when current off. Repeated application
Voltage 70° = 75.5 × 8 = 604 Time 15"
Calf quite dead on removal of current.

6th Calf weighing 100½ lbs. res: 550 Ω before + 280 Ω after death
Smaller felt electrode on forehead. and compress on right hind leg.
Voltage 104° = 94 × 8 = 752 Time 20"
Calf quite dead on removal of current.

Electrocide experiments contd:

7th Calf weighing 98 lbs. Res: 3140 w. after death 230 w.
Contact on back of neck with smaller felt electrode and right fore leg.
Voltage 105° = 95 × 8 = 760 Time 15".
Result no shock gait or heart action when current off.

8th Calf weighing 109 lbs. Res. 380 w. of
Contact right fore leg and left hind leg. wall compressed
Voltage 100° = 92 × 8 736 Time 15"
Calf not quite dead, slight attempts at gasping.
Repeated 70° = 75.5 × 8 604 Time 20".
Quite fatal.

9th A brown horse weighing 830 lbs. res: 500 w after death 200
Contact on forehead with small electrode and on left hind leg above knee with large electrode.
~~Voltage~~ Fore feet and hind feet hobbled - Horse fell.
Voltage 90° = 86 × 11 = 946 Time 25".
Horse rigid during application of current and after removal, no heart action or sign of life visible.
Repeated application of current to observe effect. The spasm equally great both on hind + fore legs

The low resistances observed in all these cases were measured with a Siemens Universal galvanometer and are attributable to the ~~hot~~ zinc sulphate solution which was kept hot all the time.

Present Mr H. P. Brown, Dr MacDonald
The Demonstrator of Physiology in the University of Penna
Two other surgeons, and a gentleman from the Albany commission office.

log 0.00388 = 0.0016628
×23.8 = 0.0400050

log 9.528 = 0.97900
0.04005
1.01905

log 9.662 = 0.98507
0.02395
1.02512

Some Data in Connection with the Brooklyn Electrical Determination of the Underground System.

The voltage of the lamps being stated as 115, + the drop in the main as 1% makes the pressure at the feeder terminal 116.16 (say 116.2) and at 12% drop in the feeder = 132 volts
" 10% " " " " = 129.17 " say 129.2

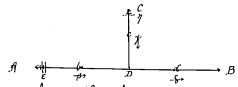
Taking 1 mil foot as = 9.718 B.A. units at 0° C = 10.664 B.A.U. @ 75°F = 26°C
= 10.548 Legal U. @ 24°C

This is the value for 100% conductivity.
Taking the commercial copper as 97% conductivity, this becomes
= 10.868 legal ohms @ 24°C

On the basis of the tables in Everett's work the sp. res. of annealed copper in legal ohm is given at 15844.00. One foot of copper would thus be 30.48 × 15844 = 48280 ohm. U. one inch diam. has an area of 0.7854 sq. in. = 7854 × 6.4516 = 5.0671 sq. cms. Therefore a one inch rod or 1000000 circular mil would have a res. of 9.528 legal U @ 0°C.
or 1 " " foot " " " " 9.528 legal " .
10.145 " @ 24°C

On the basis of a statement in the same work that a wire 1 mm long 1 mm diam has a resistance of 0.0[illegible] Ω. 1 foot long would be 0.0[illegible] = and 1 mil in diam would be 9.662 leg. Ω @ 0°C. = 10.596 " legal @ 75°F
Taking the first reckoning of 10.868 @ 24°C as standard we have

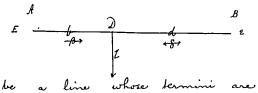
S.G.N.	Circular Mils	Res. per foot	S.G.N.	Circular Mil	Res. per foot	Conductivity per foot	S.G.N.	Circular Mil	Conductivity per foot
3	3000	0.003623	220	220,000	0.000004940	20,260	3	3000	276
5	5000	0.002,1736	240	240,000	0.000004529	22,080	5	5000	460
8	8000	0.001,3585	260	260,000	0.000004180	23,920	8	8000	736
12	12,000	0.000,9069	280	280,000	0.000003881	25,760	12	12,000	1104
15	15000	0.000,7245	300	300,000	0.000003623	27,600	15	15,000	1380
20	20,000	0.000,5225	320	320,000	0.000003396	29,440	20	20,000	1840
25	25,000	0.000,4347	340	340,000	0.000003196	31,280	25	25,000	2300
30	30,000	0.000,3623	360	360,000	0.000003019	33,120	30	30,000	2760
35	35,000	0.000,3105	380	380,000	0.000002860	34,970	35	35,000	3220
40	40,000	0.000,2613	400	400,000	0.000002713	36,810	40	40,000	3680
45	45,000	0.000,2415	425	425,000	0.000002557	39,110	45	45,000	4140
50	50,000	0.000,2174	450	450,000	0.000002415	41,410	50	50,000	4600
55	55,000	0.000,1976	475	475,000	0.000002288	43,710	55	55,000	5060
60	60,000	0.000,1812	500	500,000	0.000002174	46,010	60	60,000	5520
65	65,000	0.000,1671	525	525,000	0.000002070	48,300	65	65,000	5980
70	70,000	0.000,1553	550	550,000	0.000001976	50,610	70	70,000	6440
75	75,000	0.000,1449	575	575,000	0.000001890	52,910	75	75,000	6900
80	80,000	0.000,1307	600	600,000	0.000001812	55,210	80	80,000	7360
85	85,000	0.000,1278					85	85,000	7820
90	90,000	0.000,1208					90	90,000	8280
95	95,000	0.000,1144					95	95,000	8740
100	100,000	0.000,1087					100	100,000	9200
110	110,000	0.000,0988					110	110,000	10,120
120	120,000	0.000,0907					120	120,000	11,040
130	130,000	0.000,0836					130	130,000	11,960
140	140,000	0.000,0776					140	140,000	12,880
150	150,000	0.000,0725					150	150,000	13,800
160	160,000	0.000,0679					160	160,000	14,720
170	170,000	0.000,0639					170	170,000	15,640
180	180,000	0.000,0603					180	180,000	16,560
190	190,000	0.000,0572					190	190,000	17,480
200	200,000	0.000,0522					200	200,000	18,400



If AB be a line through which a current β flows from an EMF ε and if at the point D another current be grafted on it from EMF γ we have the following conditions of current and potential before and after the operation.

	Before	After	Variation
β	$\dfrac{\varepsilon}{b+d}$,	$\dfrac{\varepsilon-\gamma\left(\frac{d}{c+d}\right)}{b+\frac{cd}{c+d}}$,	$-\dfrac{d\left\{\gamma-\varepsilon\frac{d}{b+d}\right\}}{bc+bd+cd}$
δ	$\dfrac{\varepsilon}{b+d}$,	$\dfrac{\varepsilon c+\gamma b}{bc+bd+cd}$,	$+\dfrac{b\left\{\gamma-\varepsilon\frac{d}{b+d}\right\}}{bc+bd+cd}$
pot. @ D	$\dfrac{d\varepsilon}{b+d}$,	$\dfrac{cd\varepsilon+bd\gamma}{bc+bd+cd}$,	$+\dfrac{bd\left\{\varepsilon(c-d)-\gamma(c-d-b)\right\}}{(b+d)(bc+bd+cd)}$

So that if $b=d$, whatever be the res: or emf grafted at D on the main circuit the variations of current strength on each side of D will be equal and opposite.



If A ~~and~~ B be a line whose termini are maintained at potentials E and ε respectively, with the same notation we have

$$\beta = \frac{E(d+l)-\varepsilon l}{bd+bl+dl} \qquad \delta = \frac{\varepsilon(b+l)-El}{bd+bl+dl}$$

So that if we consider the potential difference between E and D before and after the application of the emf ε we have.

Before	After	Variation
$\dfrac{b(Ed+\varepsilon b)}{bd+bl+dl}$	$\dfrac{bE(d+l)-b\varepsilon l}{bd+bl+dl}$	$-\dfrac{b^2\varepsilon-bl(E-\varepsilon)}{bd+bl+dl}$

Meter Experiments contd.

March 28th Thursday)

Took some measurements of the res: and counter e.m.f of a silver voltameter to see how far it would conform to the conditions demanded in an Edison station meter.

Took a strip of silver 21.8 cms long and 3.8 broad, divided it into 5 lengths 10.9 X 3.8. These were flattened, and finally cleaned with dilute acid and caustic potash. They were then fixed opposite each other and 0.5 cms apart. Wires were connected with their upper edges. The plates were then immersed in a solution of $AgNO_3$ that was made up some months ago 25% by weight. Its density under this test was 1.27 and the temperature at the time 23°c.

The beaker in which the plates stood was 13 cms high and 5 in diam.

No.	Strip	Res.	T.Z.	F.Z.	Leads	Counter emf	TZ - FZ	Temp. of solution	Area of surface of anode
1	100/10	1.1	21.00	3.50	0.02	0.018	17.5		
2		2.1	11.8	2.90		0.019	8.9	23°c.	
3		3.0	7.6	2.3		0.017	5.3	Plate 0.5 cms	
4		5.0	5.6	2.1		0.017	3.5	apart	
5		10.0	3.0	1.5		0.015	1.5	Area 29.26	
6		20.0	1.9	1.2		0.014	0.7		72a
7	Preceding day	3.1	14.5	3.0		0.025	8.5		
8		19	2.2	1.14		0.015	0.8		
9		3	10.3	2.7		0.022	7.6		

Hard Rubber Substitute Test

April 8th 1889.

The following tests were made of a sample of black substance intended as a substitute for rubber. Its thickness was 3/8". A sheet of hard rubber 3/8" thick was selected for comparison.

A strip was cut from each sheet, the dimensions being 15 cm X 1.35 X 0.78. In cutting the new material that smelled like ebony had a granular structure and cut off in powder was much softer than the rubber. On taking these strips placed equal and fixing them across blocks of steel, the breaking strain in the center was found to be about 100 lbs for the new material and 115 lbs for rubber which bent much more before fracture.

The spec: gravity of the real hard rubber was 1.18
" " " substitute " 1.38

The weight of two pieces of substitute were 11.09 and 10.78 respectively. After immersion for two hours in a solution of NH_4HO and acetic acid the weights were 11.11 and 10.78.

Weight of the Bipolar Dynamo

Schenectady casting	2720
Compbell "	2470
Steel shaft	170
Bearing	200
pulley	200
rail	150
rocker arm	50
iron wire in armature	460
commutator	100
armature wire	30
woodwork of frame	60
Bobbin wire	500
	7120

say 7200

April 1st Monday. Used small induction coil for preliminary experiment. Its length is 18 cms its diam 2.5. The res. of its primary 0.14 its secondary 7500.

Actuated the primary and its automatic vibrator with the 60 volt dynamo. Connected the secondary terminals to two air condensers formed of two ebonited brass disks each 17.4 cms in diam and separated by about 0.5 of an cm. Next took a spark micrometer whose electrodes are tapering points and joined them by a wire of black covered copper some 150 cms long. Twisted this covered wire round the rods of the air condensers. Ascertained that the sparks passed easily between the points of the micrometer when the distance was perhaps 0.025 cms.

April 2nd Tuesday.

Repeated this experiment with the large induction coil whose length is 51 cms and diam 20. Its primary res. is 0.205 ω and its secondary 31000. Actuated it by a mercury contact breaker using the 100 volt circuit and some 10 to 20 ohms of resistance. Tried to obtain sparks from the micrometer when short circuited as before, but without success. Many combinations were tried but even when considerable self induction was interposed in the short circuiting wire, the spark invariably failed to appear at the micrometer nor could any p.d. be detected by the tongue.

April 3rd Wednesday. Tried experiment again with small coil. When its secondary terminals were connected direct to the terminals of the micrometer no device succeeded in obtaining sparks or p.d. evidences any convenient length. So soon however as the micrometer wires were insulated and laid upon the terminals of the air condenser, sparks were immediately visible, and continued to be distinguished even when short circuiting was effected through thick copper rod. They were however very faint and could only be discerned by selecting the micrometer points. On making two coils in air round the condenser rods the with the micrometer wires these effects were still visible so that conduction under changing the colours of two leyden jars direct from the secondary terminals and taking the intervening to the micrometer these sparks after short circuiting were distinctly increased. Tried the same experiment with the large coil and succeeded in obtaining distinct sparks across an air break of any short length (not permitting a knife edge to intervene) when short circuit made with a wire and a ¼" copper rod passed above the micrometer pillars.

It was observed that when sparks were thus passing freely during this experiment between the micrometer points short circuited by a bare wire 0.1 diam and some 10 cms long, the interposition of an opaque substance such as paper or metal, caused them to cease. Happening however on the removal of the substance. The same effect was produced by interposing a sheet of transparent glass but occasionally a spark would be observed in this case. Various coloured glasses were tried and they all (obstructed apparently) the passage of the spark. Quartz however in the form of a thin section ⊥ to the axis seemed to offer very little obstruction, but another section parallel to the axis seemed to offer some obstruction less than glass.

The micrometer was then fixed in a convenient dark box admitting of a ray of light through a suitable aperture to fall upon the point short circuited as above. By observing through an eyepiece on the same principle as the Ethnoscope, it was evident that a ray passing through a metal aperture 0.5 in diam from the spark between the jars had influence on the passage of the spark at the micrometer when the intervening distance was 80 cms. The closing of this aperture by a side screen instantly stopped the spark and did also the interposition of different kinds of glass, ebonite, tube, mica, and quartz section parallel to the axis. Some

of these substances acted in different degrees, plain glass and talc being perhaps the most effective. An observer watching the sparks could tell the moment one of these substances divided the line between the two, & was noticed that whenever the spark occurred, the tongue applied to the points could detect the electrical disturbance.

Tried whether an incandescent lamp could by its light restore the micrometer spark when this was extinguished by some screen or other but without success. On removing the shutter screen the passage of the incandescent lamp across the spark connecting line extinguished that at the micrometer. Next tried an independent induction coil spark with and without a Leyden jar and tried to effect the reproduction of the extinguished micrometer spark by its aid without success.

Removed the micrometer and dark tube to a distance of about ½ metre from the Leyden jars, but spanning the distance by two cotton covered wire 0·1 diam. At this distance the mutual relation between the sparks was scarcely if at all evident.

Brought the micrometer back to its previous range and tried to substitute an arc light for the jar spark in restoring the lost micrometer spark but at a distance of some 2 metre between arc and micrometer this was not successful.

The only substances found which permitted the mutual action to pass unchecked were quartz sections at 45° to axis and rock salt, the latter even 2 cms thick.

April 4th Thursday

Inserted a powerful solenoid between of 14 layers between the two sparks so that the mutual influence took place through it axis. Excited this powerfully by an alternating current making some 230 complete periods per second. No effect from this alternating magnetic field could be discovered upon the sparking.

Made a small rock salt prism and tried to find at what particular angle of prism rotation the sparking at the micrometer was affected when all the light was cut off except through the rock salt. The prism was however too imperfect to be able to arrive at any conclusion but it certainly did interrupt the sparking contrary to the behavior of plane sections.

Arranged a plane mirror about 5 cms in diam. in such a manner as to reflect the jar spark upon the micrometer points even when the direct spark was cut off from all influence. Unmistakeable evidence of the influence being exerted by the reflected ray, though it may have been a little less decided.

Took a slip of microscope glass and 0·013" = 0·033 cm thick and found that even this thickness effectually stopped the influence, the micrometer spark ceasing on the insertion of the polished slip in the line of action.

April 5th Friday

Repeated last experiment with glass screens 0·005" = 0·011 cm thick. Also tried to ascertain by thin slips of thin glass arranged in different positions whether the effect observed was due to an influence on the dielectric or on the electrodes themselves. It seems from these trials that if the electrodes are screened the influence is cut off but if the air space is screened and the points left within view of the main spark the micrometer spark continued. On removing the short circuiting wire and replacing it by a sounder whose magnetic circuit was forcibly closed so that it possessed large self induction, the spark length was increased to 0·25 cm. At one time it seemed that the screening of one point interrupted the spark more than the screening of the other, the effect reversing with the reversal of the wires from the jars, but other experiments did not always show this. Little or no influence could be obtained by reflection from a thick silvered glass mirror, not in restoring the spark, but a simple

sheet of steel seemed to reflect the influence. A small Bunsen burner flame was thrown round the secondary after the spark had been interrupted by a screen but without success unless the flame were very close above or underneath them.

Took a glass parabolic mirror 33 cm in diam: and of about 20 cm principal focal distance, after a preliminary trial at short range succeeded in obtaining the influence by its means when the distance between the sparks were about 5 metres and the actual distance travelled over by the influence some 7 metres.

Took a second parabolic mirror similar to the above, and placed them facing one another at opposite ends of the galvanometer room some 23 metres apart. In the focus of one was set the primary spark, and at the focus of the other the micrometer point, the distance being spanned by two g.p. Zinc wires rather in excess of length. The micrometer air space was about 0·025 cm and the secondary formed the short circuit. The influence was plainly discernible but was not as complete as at short range. This may have been partly due to the variation of the primary spark from the focus. It appeared as though time were required to stimulate the reproduction of the spark on removing a screen from the line of mirror action, just in the way a spring takes time to respond by increasing amplitude to a continuous stimulus before a maximum is obtained.

April 6th Saturday

Repeated this last experiment with the same general results. Finally returned to the original conditions, forming the primary spark however between two platinum points. Interposed a number of substances to see if any others permitted the passage of the influence. Bladder, Indian skin, Sweat gum, paraffine, &c. Also among the microscopic double refracting disks, calc spar, borax, aragonite, tourmaline and quartz. Of these last there were three and one only out of all the materials tried passed the influence. No indication of the direction of action was found on this disk.

April 9th Monday

Tried the effect of a beam of sunlight upon the restoration of the spark. Simple sunlight did not succeed but sunlight condensed to a focus by a double convex lens succeeded fairly though not markedly. Tried thin sheets of amber and found one or two to be slightly successful. Succeeded in getting good results through a cube of rock salt!

April 9th Tuesday

Tried to see if there were any purely electrical disturbances in the micrometer circuit due to radiant action on the points. Found that galvanometer was disturbed by magnetic influence of induction coil. Used quadrant electrometer and found disturbances on producing primary sparks but from such tests as were made the disturbance appeared to be chiefly electrostatic due to influence of charge upon circuit and not dependent on radiant action.

Succeeded in obtaining results through films of water, solution of methyl violet, aniline brown, oil, glycerine and water, sulphate of copper and weak solution of ferrocyanide of potassium.

April 10th Wednesday

Took two glass rods 0·36 cm diam and about 2·5 long with a platinum wire 0·03 diam fixed throughout their length, and passing out freely at one extremity. The opposing ends were filed flat so that the wire section was flush with the glass surface neither receding nor protruding. These rods were clamped opposite to each other so as to bate the place of the micrometer points. Their distance arrangement was

April 8th, 1910 Test of certain specimens of non-inflammable wire

Received from Mr Insull for testing 5 specimens of wire as follows

#1 No 14 copper wire 0.056" covered to 0.20" dark red + black braid marked
silicate of soda grade 1

#2 No. 14 copper wire 0.056" covered to 0.20" red yellow braid marked
grade 1 non inflammable

#3 No. 14 copper wire 0.056" covered to 0.20" red yellow braid marked grade 2
coating rubber non inflammable

#4 2 strands each 12 # 32 B&S 0.0055" copper rubber covered, and coated with
red and black braid, marked flexible cord non inflammable

#5 2 strands each 14 0.0055" copper rubber covered and helically coated with
steel wire, green and yellow braid marked flexible cord covered
with steel wire.

Specimens of all these samples were tested with bunsen flame and found to be practically non inflammable since any flame set up was soon extinguished on isolation.

Soaking for 5 mins: in water was not found to impair the insulation of any specimens.

On forcing a current through other specimens to the melting point the behavior was as follows

#1 Melted without catching fire
#2 burst into flame on melting at two point
#3 - - - - - - - .
#4 - - - - - .
#5 - - - - -

The current used for the 1st three was about 150 amperes and for the last 2 about 50.

Data concerning Octopolar Dynamo resistance.

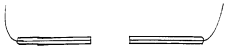
152 Commutator Blocks
456 Turns of no 10 wire @ 5.75×10^{-4} μΩ/20" each = 1.7 ft
8 complete batteries = 57 turns per battery

$57 \times 1.7 \times 5.75 \times 10^{-4}/8 = 69.7 \times 10^{-4} = .00697$
Add to this about 7" equivalent of # 12 wire .0005
Total .0075 ω.

1 h.p. 20 when est: res: .0750 = 746/3.00 lamps @ 200 w each
= 860 amperes.

Assuming that the heat from the forcable current could be reduced 50% the temperature rise would if there were no convection be also only 50% but with convection into account it would be more say 70%.

A glass tube electrode and secondary spark
B primary spark between pt. wire vertical
C secondary terminal of induction coil



Electrical Oscillation Experiment

was as shown. Distance between primary + secondary sparks 10 cm
In the 1st trial with the two glass rods at an angle of 165° and converging towards primary spark. the distance between them being 0.02 cm. the number of sparks passing during 25 primary make and breaks was 50 unscreened and 1 screened.
On making the angle 150° and keeping the same distance the number of unscreened sparks was 47 of screened 2.
On making the angle 143° diverging from the primary spark the number of unscreened sparks was 25 of screened 0.
Cleaned the surfaces of the electrodes and repeated last trial with the distance between them 0.017 and the angle 143½° the number of unscreened sparks 43 and the screened 45.
With the angle of 147° and the same distance the number of unscreened sparks 25 and screened 29.

The platinum wire were then drilled out for a distance of about 0.05 cm with a needle drill, so that they were certain to be screened at their extremities from direct radiation. At a distance of 27 cms from the primary spark the results were :—

No: of contacts	∠ between electrods	Dist: apart	Screened spark	Unscreened sp.
25	180°	0.225 cm	29	38
		0.20 "	11	
		0.15 "	42	44
		0.275 "	12	12

There can thus be no question that the effect observed takes place almost entirely at the surface of the electrodes.

Tried small fragments of the following substances to see if the influence would pass through them. They were held before the ⅛" orifice in the brass shutter. Hard rubber 0.005" camphor iodine scales, soft rubber, animal glue. $Fe\,PO_4$, tartrate of iron, all these failed.

A solution of bichromate of potash as a film upon the orifice stopped the influence, contrary to the behavior of the other aqueous solutions already tried.

Ascertained that a thickness of glass ~~1/5000~~" = 0.00025 cm invariably stopped the influence.

April 11th Thursday

Tried scale or thin crystals of the following substances without success

Cellulose 0.027
Bichromate of potash
Sulphate carbonate
Cinnabar
Mercury methyl chloride
" ethyl "
Tartaric acid $C_4H_6O_6$
Citric acid $C_6H_8O_7$
Boric acid B_2O_3
Iron Borotartrate Fe
Iron Mallic $Fe\,C_4H_4O_5$
Phosphoric acid PO_4
granular
Sodium Metaphosphate $Na\,PO_3$
Potassium phosphate HK_2PO_4
Sodic oxalate $Na_2C_2H_2O_4$
Potassium Tartrate
Potassium ferrocyanide $K_4C_6N_6Fe$
" ferricyanide $K_3C_6N_6Fe$
" sulphate K_2SO_4
" chromate K_2CrO_4
Magnesium nitrate $Mg\,NO_3$
Iron amm. sulphate $Fe_2(NH_4)_2SO_4$
Nickel " " $Ni_2(NH_4)_2SO_4$
Aluminate of potash
Sulphocyanide of guanidin
Sulphur cyetal

Problem. To find the dimensions of a steel rope which should be capable of bearing the gravitating pull exerted between the earth and the sun.

The attractive pull exerted is $F = \frac{cSe}{d^2}$

where S is the sun's mass $= 18 \cdot 42 \times 10^{32}$

e - - earth's $= 6 \cdot 14 \times 10^{27}$

d - - intervening distance $= 1 \cdot 487 \times 10^{13}$

c - - gravitation constant $= 6 \cdot 48 \times 10^{-8}$

$$F = \frac{1 \cdot 842 \times 6 \cdot 14 \times 6 \cdot 48 \times 10^{26}}{1 \cdot 487 \times 1 \cdot 487} = \frac{73 \cdot 3 \times 10^{26}}{2 \cdot 211}$$

$$= 3 \cdot 315 \times 10^{27}$$

The tenacity of steel (low) is stated to be $7 \cdot 93 \times 10^{9}$ so that the area of the rope would have to be

$$\frac{3 \cdot 315}{0 \cdot 793} \times 10^{17} = 4 \cdot 18 \times 10^{17} = 41 \cdot 8 \times 10^{16}$$

The diam $= 7 \cdot 3 \times 10^{8}$ cm. $= 450$ miles.

The steel rope would have to be 450 miles in diameter.

The earths velocity in her orbit being about $2 \cdot 96 \times 10^{6}$ her centrifugal force must be

$$F = \frac{2 \cdot 96 \times 2 \cdot 96 \times 6 \cdot 14 \times 10^{26}}{1 \cdot 487} =$$

$$= 3 \cdot 618 \times 10^{27}$$

The two expressions for F should coincide.

Determination of sp: gr: of certain specimen of transparent mineral sent by Mr Davenport of 81 Howard St Detroit Mich

Weight in air	0·7340 gm	Wt silken cord 0·0005	Tare wt 0·7335
- - distilled water	0·3966	- - - 0·0005	- - 0·3961
			0·3374

Temp. water 21°C. where density 0·998

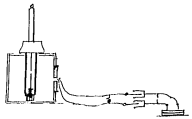
$$\frac{0 \cdot 7335}{0 \cdot 3374} \times 0 \cdot 998 = 2 \cdot 170.$$

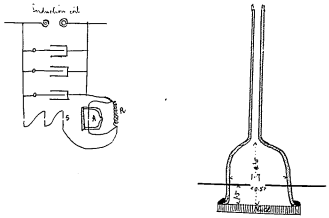
The stone will not scratch sapphire or quartz.

Is slightly yellow, irregular, brittle.

Slightly positive ~~sol~~ electrically when rubbed.

Presumed to be some of the quartz group





Electrical radiance experiment.
Tried the following solutions as droplets held in a hole about $\frac{1}{16}$ square in a glass plate.

Passing influence	Obstructing influence
	$Pt\ Cl_4$
	$K\ NO$
	$(NH_4)Cl$
	$(NH_3)\ H_2O$

Tried sapphire, glycerine, and different qualities of glass, also cassidar balsam also without success. But found that thin films of $Ce\,SO_4$ crystal, mica, and $H_2\,Mg\,O_2$ are just on the dividing line between transmitters and obstructors, thin films allowing the influence to pass more or less readily.

April 12th & 13th

Connected up a flipper arc lamp in the lantern box and closed its lens aperture with a wooden plug in the centre of which a small hole 1·25 cms was left. This hole and the entire plug was blackened. On each side of it was screwed a brass plate with two clamp screws. By means of these clamps, wire could be fixed with their ends at the centre of the hole and at any desired proximity.

Wire of Brass copper lead magnesium solder platinum, cadmium, zinc, tin and iron all it was found that the ignition of the arc at a distance of 18 cms would restore the spark and the interception of the beam stopped it. But the adjustment had in some cases made closely

Ascertained that the influence was transmitted by sections of fluor spar and ammonia alum.

April 14th

Received from Professor Eglatine (Columbia Coll) for Mr Edison 3 quartz prisms and one of Fluor Spar.

By means of these prisms (April 18th) ascertained that the rays which affected the micrometer spark were chiefly confined to the ultra-violet spectrum.

April 19th

Made a dutch metal electroscope and after producing divergence with 500 and also 100 volts, tried to see if insolation directly produced any change but was unable to observe any.

April 20th

Arranged an induction coil as shown. Three leyden jars in its cct. and three primary air sparks together with a rectangular coil of three and three wound on a stem. This coil was charged by an spark distance of 0·5 in a glass chamber A through which walls the platinum wire was sealed. The face of this bell shaped glass chamber was a plate of rock salt 0·4 cm thick sealed on with sealing wax. By means of the glass tube the chamber was connected with the mercury pump and was exhausted. During the process of exhaustion it was observed that with A facing one spark S waves of rosy light ran up the whole length of connection tube (about 100 cms) to the pump. This took place so long as one wire (either) remained connected between A and R but ceased when A and R were totally disconnected. When the vacuum became higher this effect did not take place.

On removing A sparks would traverse occasionally the three breaks S and the resistance R. On connecting A to R it was observed that the passage of a spark at A acting as a short circuit to R greatly strengthened and promoted the sparks at S. The influence usually observed at ordinary atmospheric pressure was here quite discounted as the following observations show together with the remarkable fact that very seldom any sparks at S occurred without spark at A, and consequently the influence of a spark at A set up by a transparent substance not only affected A's spark but also that at S.

List of substances found to be opaque and transparent up to present date in electrical radiance

List of Transparent substances

Rocksalt
quartz
Clear colorless amethyst
ammonia alum
Thin mica, and bruciite.
Water
Ice
Many aqueous solutions of salts

List of Opaque substances

Metals in plates
Carbon
Glass even $\frac{1}{10,000}$". 2.5μ
cellulose
rubber hard soft
canada balsam
Beryl
Tourmaline
Purple amethyst
Aragonite
Celestite
Barium sulphate
Lead carbonate
Camphor
iodine
animal glue
Sale
Solution of $Pt\,Cl_4$ / $K_2\,Fe_2\,C_6$ } in water.
Potash alum.
Agate

Electrical Radiance experiment.

Distance between sparks S and spark A		2.5 cms.	Facing each other
In 25 contacts	air separation only	23 sparks	at A.
- - -	glass 0.1 thick inserted	6 -	- A.
Distance between sparks increased to 7.5 cms.			
In 25 contacts	air separation only	12	
	rocksalt plate in hand	24	
	air	17	
	rocksalt held in hand	20	
	air	18	
	rocksalt held in place	16	
	brass gauge	13	
	air	19	
	copper sheet	8	
	air	11	
	copper sheet	4	
	air	18	
	hard rubber sheet	10	
	air	22	
	hard rubber	11	
	air	25	
	glass plate	10	
	air	20	
	glass	8	
Distance between sparks increased to 16.5 cms			
In 25 contacts	air separation	15	
	rocksalt	12	
	air	10	
	brass gauge	9	
	air	15	
	copper sheet	2 at A	5 at S
	air	14	- - 14 - -
	hard rubber	6	- - 6 - -
	air	11	- - 11 - -
	glass	1	- " 2 - -

Means for

air	rocksalt	brass gauge	copper sheet	rubber sheet
18	20	13	6	11

glass sheet
9

Means: air 13 rocksalt 12 brass gauge 9 copper sheet 2 hard rubber 11 glass 1

23rd April.

Tried a number of different minerals for transmissive power, the specimens having been lent by Prof. Egleston of Columbia College.

Some 50 quartz specimens, sections were tried, and of these only two were found to be opaque. Both were parallel to the axis but one was concave. The other 24 mm square was a brown plate. A small lenticular piece from this was transparent as also was the whole section laterally. The following opaque minerals were found.

Tourmaline. Clear transparent beryl. Transparent carbonate of lead, Emerald Beryl, Aragonite. Alum. Barium sulphate.

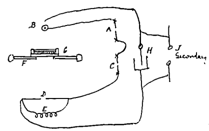
Finding that a section of quartz || axis was transparent, carefully examined the one of the Edison collection already recorded as opaque. Discovered that it was backed by a glass plate cemented with canada Balsam. On removing these the plate was at once transparent. Also two hyperbolic plates of quartz united by canada balsam in the Edison collection were partly separated and cleaned. The separate sections were transparent but where still united by balsam, the pair remained opaque.

Amethyst was found to be transparent when clear and colorless and thicker specimens in a partly colored and partly clear state were transparent to the influence whenever the clear portions were brought over the window.

A small cube (1 cm) of smoky quartz was transparent to influence.

A Primary spark shaded
B - - active + horizontal
C - - shaded
D Passive spark
E Induction coil of ten turns
F Plate of wood held in retort ring
G - - quartz surmounted by ring of ground glass fixed on by wax
H 2 Leyden jars
J Secondary of induction coil.

Distance from B & D 8.5 cms.



26th April Friday.

Exhausted afresh the vacuum tube described on page 101. Obtained a vacuum of 0.0018 cms or 1/42,000. Sealed this tube at that pressure but was unable to obtain anything influence with it beyond a very feeble effect. Broke the seal and tried again but owing to the big air space it was very difficult to ascertain how far it then exhibited the influence.

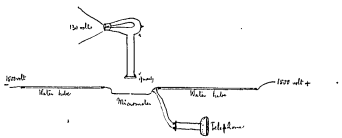
As a matter of interest observed the rise of the mercury in the guage during exhaustion. The case was not a perfectly illustrative one as there was a slight leak in the window seal.

Time	20"	38"	50"	1'07" 67	1'28" 88	1.42 102	1.58 118	2.07 127	2.16 136	2.24 144	2.33 153	2.45 165	3.0 180	3.14 194	3.29 209
Rise	31	41	46	51	56	58.5	61	62	63	64	65	66	67	68	69
Time	3'48" 228	4.15 255	4.45 285	4.58 298	5.18 318	5.41 341	6.05 365	6.34 394	7.11 431	8.00 480	10.15 615				
Rise	39. 70	40 71	41 72	41.5 72.5	42 73	42.5 73.5	43 74	43.5 74.5	44 75	44.5 75.5	45.0 76				

27th April Saturday

Arranged apparatus for experimenting on liquids.

No. of Obs	Thickness of plate	Depth of liquid layer	Liquid	Dist B & G	Dist: G & D	Behavior	Spark at B	Spark at D	Conductivity	Color
1	0.3	0.1	H_2O	4.5	3.8	Transparent	0.26	0.10		Trans. P.
2		circa	Kerosene comm.			Opaque			Ins:	"
3		-	Naptha -			"			"	"
4		-	Oleum Bayii			"			"	Yellow TL
5		-	- of apple			20% transp:			"	T.P.
6		-	Chloride of Benzoyl			Opaque			-	T.P.
7		-	Capsicutid			"			—	Yellow TL
8		-	Orthobromide of Toluol			-			—	T.P.
9		-	Alcohol pseudo Butyric			Transparent			-	T.P.
10		-	Ether carbonic			"			-	Tp
11		-	Tincture Ambergris			20% Tp			Non Ins:	Yellow Tp
12		-	Oleum Verbena			50% Tp			Ins.	Tp
13	0.3+0.15	0.1	Glycerine cp.			Opaque			"	Tp
14			Absolute alcohol			Transparent			Not good Ins	Tp.
15			Concent: Ether			"			Ins.	Tp.
16			{ Collodion thin film			30% Tp				Tp
			{ 0.1 cm layer			Opaque				
17			{ Benzole thin film			10% Tb				Tp
			{ 0.1 cm layer			Opaque				-
18			Gasolene			10% Tp				"
19			Rhigolene			15% Tp				-



Experiment were tried with wire whose extremities were in opposed juxtaposition towards in alcohol and in water a few cms below the active spark. The spark length was much shorter than in air. The difficulty with alcohol were the continual explosions. With water it seemed that when the wire were close up to the surface a slight effect was obtainable, but not sufficiently marked to be certain, but when deeply immersed there was no effect to be detected.

May 3rd Friday. Connected the 1500-volt terminals to the sparking points through two tubes 23" long ½" bore full of tap water with small nickel wire 1" long inserted as electrode. With this arrangement obtained a distinct striking distance between opposed points of about 0.021 cm in air.

Took a Nernst lamp that had a ⅞" glass tube 6" long melted horizontally into the side and closed by a mica plate. With this at 113 volts tried to obtain effect on a passive spark without success.

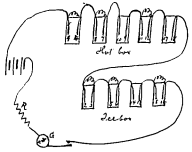
May 4th Saturday

Took another lamp fitted with the same tube and used the 130 volt circuit for its supply. When this was fixed so that the rays were thrown vertically down upon the points connected with the 1500 volt circuit a distinct effect could be obtained. That is to say sparks would break across under the influence of the light when they ceased altogether during the removal. The same effect was produced with the spark from the induction coil.

Finally inserted a telephone in the 1500 volt circuit and when the points were at such a distance that no sparks were heard to pass but just so that a very small motion of the screw would allow their passage, on lighting the lamp they were immediately audible, and the usual effects of rock salt rubber etc. were also recognized.

Meteorological Record.

Date	Time	Barometer Reading Inches	Corrs.	Temper. of Barom.	Barom. reduced to 32° F.	Thermometer Max.	Min.	Thermometer exposed at Dry	Wet	Rainfall last 24 hr.	Clouds	Wind	Weather Remarks
May 1st	Noon	29.834	75.79	73°	29.705	63°	38°	61°	52°	—	—		Fine
" 2nd	"	29.784	75.66	74°	29.659	63°	39°	52°	45°	—			Fine
" 3rd	"	29.834	75.78	67°	29.759	72°	30°	67°	57°	—			Fine
" 4th	"	29.900	75.93	75°	29.771	66°	40°	66°	54°	—	—	East	Fine & fog
" 5th	"	29.932	76.03	81°	29.795	80°	47°	78°	67°	—	—	"	Fine
" 6th	"	29.938	76.04	74°	29.800	90°	49°	82°	58°	—	—	"	Fine
" 7th	"	29.946	76.05	77°	29.811	91°	46°	80°	68°	—	—	"	Fine
" 8th	"	29.806	75.84	74°	29.680	93°	49°	84°	72°	—	—	"	Fine
" 9th	"	29.504	75.04	80°	29.391	100°	60°	93°	72°	—	—	West	Fine
" 10th	"	29.820	75.88	75°	29.727	79°	46°	79	68°	.013	—	West	Fair
" 11th	"	29.764	75.60	81°	29.617	86°	55°	83°	69°	—	—	West	Fair
" 12th	"	29.816	75.74	70°	29.702	80°	54°	70°	66°	—	—	East	Fair
" 13th	"	29.634	75.40	78°	29.546	80°	60°	68°	65°	0.06	—	West	Overcast
" 14th	"	29.838	75.91	72°	29.766	90°	62°	84°	70°	—	—	West	Fair
" 15th	"	29.970	76.13	73°	29.867	96°	52°	84°	76	—	—	South	Fair
" 16th	"	30.240	76.81	75°	30.111	96°	51°	90°	84°	—	—		Fine
" 17th	"	30.196	76.71	78°	30.058	96°	64°	86°	79°	—	—	South	Fine
" 18th	"	30.135	76.61	71°	30.038	92°	63°	70°	67°	0.04	—		Heavy
" 19th	"	29.940	75.90	70°	29.721	76°	67°	72°	70°	0.67	—		Rain
" 20th	"	29.572	75.12	70°	29.458	80°	63°	78°	73°	0.60	—		Damp
" 21st	"	29.646	75.31	66°	29.544	97°	50°	70°	64°	0.04	Cirro-cumulus	S.W.	Fair
" 22nd	"	29.734	75.53	63°	29.641	88°	52°	65°	60°	0.13	"	N.E.	Fair
" 23rd	"	29.834	75.76	73°	29.864	78°	40°	70°	62°	0.00	—	S.W.	Fair
" 24th	"	29.836	75.78	68°	29.725	84°	50°	72°	64°	—			Overcast
" 25th	"	29.832	75.75	62°	29.762	82°	50°	52°	50°	0.49			Rain
" 26th	"	29.710	75.46	60°	29.626	73°	46°	48°	47°	0.41			Rain
" 27th	"	29.702	75.45	63°	29.609	74°	47°	70°	62°	0.32		W	Showers
" 28th	"	29.894	75.92	64°	29.697	78°	45°	71°	63°	0.30			Rain
" 29th	"	29.964	76.12	62°	29.819	82°	53°	78°	74°	—		S	Wet
" 30th	"	29.944	76.06	66°	29.842	86°	46°	88°	66	0.21		S	Showy
June 1st	"	29.892	75.97	69°	29.697	71°	64°	66°	64°	0.26		S	Overcast
" 2nd	"	29.890	75.96	68°	29.704	92°	56°	68°	67°	0.28			Showy
" 3rd	"	29.880	75.90	70°	29.704	91°	50°	80°	67°	—		SW	Fine
" 4th	"	29.632	75.37	69°	29.521	91°	58°	76°	67°	—		W	Fine
" 5th	"	29.500	74.93	70°	29.326	76°	57°	72°	65°	—		SW	Fair
" 6th	"	29.620	75.34	66	29.518	77°	50°	60°	58°	0.03		S	Fair
" 7th	"	29.872	75.89	66°	29.770	84°	46°	70°	66°	—		W	Fair
" 8th	"	29.740	75.54	70°	29.626	84°	60°	76°	70°	—			Overcast
" 9th	"	29.914	76.02	69°	29.738	90°	50°	80°	80°	0.02			Fair
" 10th	"	29.896	76.16	67°	29.838	100°	50°	76°	76°	0.02			Fair
" 11th	"	29.702	76.09	75°	29.813	100°	68°	91°	72°	0.02		W	Rain
" 12th	"	29.102	76.12	76°	29.010	93°	68°	88°	73°	0.13		W	Rain
" 13th	"	29.102	76.19	76°	29.819	92°	62°	86°	78°	—		W	Rain
" 14th	"	29.276	75.39	74°	29.750	93°	60°	82°	78°	—			Fair
" 15th	"	30.496	76.32	78°	29.900	100°	64°	89°	82°	—		SW	Fair
" 16th	"	29.916	76.00	76°	29.724	91°	67°	82°	73°	0.70		S	Fair
" 17th	"	29.908	75.93	77°	29.659	94°	65°	82°	79°	0.00		S	Fair
" 18th	"	29.772	75.62	69°	29.701	78°	60°	72°	68°	0.37			Fair
" 19th	"	29.896	75.98	77°	29.672	88°	68°	82°	76°	—	Rainbow	SW	Fair
" 20th	"	29.890	75.89	77°	29.755	88°	70°	78°	76°	—			Fair
" 21st	"	29.740	75.51	76°	29.658	89°	70°	75°	68°	—		N	Fair
" 22nd	"	30.306	76.49	71°	30.098	78°	64°	70°	65°	—	—	N	Fair
" 23rd	"	30.330	77.03	70°	30.218	76°	52°	72°	68°	—	—	NE	Fair
" 24th	"	30.284	76.92	70°	30.170	76°	53°	74°	67°	—		E	Fair
" 25th	"	30.046	76.32	72°	29.926	76°	60°	70°	72°	—		E	Hazy
" 26th	"	30.090	76.40	70°	29.972	90°	62°	80°	75	—		E	Fair
" 27th	"	30.090	76.42	78°	29.966	90°	62°	80°	75°	—		E	Fair
" 28th	"	30.012	76.24	73°	29.871	87°	71°	78°	77°	—		E	Fair
" 29th	"	30.032	76.28	76°	29.866	90°	70°	79°	75°	—		NE	Rain
" 30th	"	29.946	76.10	80°	29.932	90°	67°	76°	66°	0.24		N	"
July 1st	"	29.946	76.13	76°	29.688	72°	59°	68°	64°	0.35		N	"
" 2nd	"	29.884	75.98	76°	29.625	72°	58°	68°	63°	1.30		Calm	"
" 3rd	"	29.934	76.11	69°	29.884	75°	51°	70°	64°	1.60			"
" 4th	"	29.934	76.11	69°	29.884	75°	51°	70°	64°	0.04			Fair
" 5th	"	29.53	75.03	75°	30.002	80°	62°	75°	70°	—		NE	Rain
" 6th	"	30.124	76.59	79°	30.008	85°	62°	78°	72°	—		E	Fair
" 7th	"	30.024	76.25	76°	30.032	89°	62°	80°	71°	—			Fair
" 8th	"	30.024	76.26	77°	29.996	92°	65°	80°	71°	—		N	Fair
" 9th	"	29.894	75.99	77°	29.794	92°	65°	82°	72°	—		SW	Fair
" 10th	"	29.800	75.77	79°	29.692	90°	65°	82°	72°	0.11			Showy
" 11th	"	29.760	75.66	80°	29.716	93°	69°	78°	75°	—			
" 12th	"	29.784	75.74	73°	29.744	84°	64°	79°	71°	—		E	Fair
" 13th	"	29.784	75.74	73°	29.744	84°	64°	72°	71°	0.10		E	Fair
" 14th	"	29.850	75.91	77°	29.775	88°	65°	75°	72°	0.00			Overcast
" 15th	"	29.886	75.98	77°	29.790	90°	66°	80°	74°	—		NW	Fair
" 16th	"	29.900	75.98	76°	29.818	92°	68°	78°	75°	—		W	Fair
" 17th	"	29.814	75.72	76°	29.679	81°	62°	79°	75°	—		NW	Overcast
" 18th	"	29.946	76.16	75°	29.862	90°	66°	80°	76°	0.20		N	Fair
" 19th	"	29.945	76.10	78°	29.807	87°	67°	79°	74°	—		NW	Showy
" 20th	"	29.925	76.15	79°	29.844	87°	68°	79°	74°	—			Showy
" 21st	"	29.806	76.31	79°	29.711	85°	68°	80°	74°	—		E	Fair
" 22nd	"	29.770	76.15	76°	29.739	85°	62°	81°	75°	—		E	Fair
" 23rd	"	30.114	76.88	78°	29.881	85°	62°	81°	71°	—		NW	Fair
" 24th	"	29.730	75.82	71°	29.613	84°	70°	70°	77°	1.13		NE	Showy
" 25th	"	29.838	76.80	71°	29.727	78°	70°	70°	69°	—		N	Rain
" 26th	"	29.842	76.00	74°	29.744	78°	66°	69°	68°	—			
" 27th	"	29.732	75.53	74°	29.600	84°	70°	76°	74°	0.22		NE	Rain
" 28th	"	29.946	76.07	74°	29.820	86°	68°	82°	80°	0.00		E	
" 29th	"												
" 30th	"												
" 31st	"												



Meterexperiment, May 6th 1889

Experiment was made with a set of 9 meters of new pattern. Solution was of sp. gr. = 1.110, and of acidity of 8 drops of 10% N.S. having been boiled and filtered 3 weeks before starting the test. Lines were varnished on backside and edges, amalgamated while hot, on 4th of May, dried for 36 hs.

Distance between plates = 1/4".

Monday, 6th May 1889.

The plates were weighed, and put into their bottles, where they remained to May 9th.

No of plates	Weight on 6th May	Weight on 9th May	Loss	Gain	Meters connected in series	Resistance of meters	Place of meter	Remarks
4	118.162	117.593	.002	.034 .568	No 10	2.050 Ω	Hot box	
3	114.870	115.438		.020				
2	126.166	126.6885			No 7	4.107 Ω	Ice box	
1	116.236	115.765	.471	.051	No 9			
5	126.731	126.290	.441					
6	122.1715	122.6960		.034 .425	No 4	4.096 Ω	"	
7	116.844	117.375		.531	6			
8	120.921	120.248	.573	.002	No 12	2.053 Ω	Hot box	Smutted (slightly)
9	120.931	121.572		.641			"	"
10	127.742	126.906	.876	.035				
11	119.340	118.729	.611					
12	116.946	117.515		.002 .569	No 11	2.050 Ω	"	"
13	116.503	116.965		.462				
14	126.637	126.150	.487	.035			Ice box	Smutted (slightly)
15	120.280	119.405	.875					
16	126.136	126.902		.109 .766	No 1/3	4.158 Ω	"	
17	128.847	127.952	.895				Hot box	slightly smutted
18	127.279	128.119		.055 .840				

Plates No 2/3, 5/6, 13/14, 15/16 were contained in a Icebox, enveloped in ice, and kept at an average temperature of 40° F. Plates No. 1/4, 7/12, 9/11, 11/12, 17/18 were kept in a box warmed by a 16 c.p. lamp to an average temperature of 90° F. The current (strength) of 15 milliampères from 2 Bunsenells was passed through the meters for 50 hs, when the plates were taken out of their places, dried for only 1/2 h and weighed, the result of which is given above.

Out of the above given figures one can easily see that the loss prevail over the gain; this shows, that the solution was too acid, dissolving more time than precipitating.

Friday 10th May. Another test was made, in order to see the absolute effect of the solution being too acid:

12 plates were amalgamated as usually, and put aside in their bottles, containing solutions of different degrees of acidity (sp. gr. 1.110), remaining there for 68 hs.

No. plates	Weight on 10th May	Weight on 13th May	Loss	Acidity of solution
1	87.221	87.215	.006	Same as in
2	88.587	88.580	.007	foregoing test
3	85.723	85.702	.021	Added to smth.
4	79.190	78.155	.035	of the acid. 1 drop
5	83.700	83.640	.060	H_2SO_4
6	89.410	89.380	.030	added to the
7	85.910	85.875	.035	2 dr. H_2SO_4
8	79.721	79.710	.011	Added 3 dr.
9	88.463	88.401	.062	H_2SO_4
10	78.149	78.098	.051	+ 4 dr.
11	67.234	67.195	.039	H_2SO_4
12	78.543	78.500	.043	+ 5 dr. H_2SO_4.

Results of Motor Experiment on last page

No of plate	Weight before test	Weight after test	Gain or Loss	Bromphograins	Schumann by	Temp. °C. Mean	Res. of lamp @ temp.	Mean Loss + Gain				
1	116·365	117·763	−0·602	−0·025	2·050 w	32°	2·057	0·585				
2	114·870	115·868	+0·598									
3	116·236	115·765	−0·471	−0·051	4·107	4·5°	4·070	0·446				
4	126·736	126·682	+0·620									
5	126·731	126·290	−0·441	−0·016	4·096	4·5°	4·059	0·433				
6	121·515	121·940	+0·425									
7	116·864	117·375	+0·531	−0·014	2·053	32°	2·060	0·552				
8	120·851	120·278	−0·573									
9	120·731	121·572	+0·841	−0·035	∞	32°	∞	0·859				
10	127·782	126·906	−0·876									
11	114·360	114·749	−0·611	−0·042	2·050	32°	2·087	0·590				
12	116·826	117·415	+0·569									
13	116·503	116·965	+0·462	−0·025	4·158	4·5°	4·121	0·475				
14	126·637	126·150	−0·487									
15	120·280	119·405	−0·875	−0·109	∞	4·5°	∞	0·820				
16	126·136	126·902	+0·766	−0·059				0·870				
17	128·867	127·972	−0·895									
18	127·279	128·119	+0·840	−0·055	∞	32°	∞	0·868				

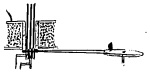
No of plate	Full Gain Rotor Weight	Mean Full Current W/t	W−10	Ratio W−10 / W	Res. = (W−10)/W	Mean Res.					
9, 10	0·859										
		0·866									
15, 16	0·870										
17, 18	0·868										
1, 2		0·281	0·281	0·480	0·988	1·041 @ 32°C					
7, 8		0·314	0·314	0·569	1·272						
11, 12		0·276	0·276	0·468	0·968						
2, 3		0·420	0·420	0·942	3·833	3·761 @ 4·5°C.					
5, 6		0·433	0·433	1·00	4·059						
13, 14		0·391	0·391	0·823	3·392						

Particulars of Phonograph Motor wound for Edison Light Co.

Field magnets wound with #30 0·012" wire Res: 170ω covered to 0·032"
Armature - - #35 0·005" " 30ω covered to 0·012"
about 1ω to the block.

At Factory motor run with 1 lamp + 60ω in ~~both~~ each circuit separately.
At laboratory run with 170ω in circuit of both + 40ω in cct: of armature.

The current in the armature cct was 0·40 amp: armature stopped
0·28 - - running.



May 15th

One large carbon was drilled out to hold within it a smaller concentrically. The two fitted into the a cylindrical shaft cut through the core of an electromagnet. This latter was fixed but the carbons could be thrown on their vertical axis by means of a separate wheel and pulley.

On passing the current through the electromagnet and so into the carbons bridged for contact, an arc was set up which rotated itself against the direction of the current in the magnet. This was accounted for by Ampère's law. If the electromagnet was left out of circuit then the arc burned at one spot and this spot did not shift on rotating the carbons nor was easy to cause its shifting by means of a separate electromagnet.

To find the coiling space required for 45w and also for 30w of No 35 B.W.G. copper wire having 2.422 feet per ohm.
= 108.9 feet for 45w and 72.4 feet.

Determination of the Constant of the Black Heavy coil Galvo.

17th May 89.

The two silver plates 11 X 2.7 cms used in a previous experiment were here employed immersed to a depth of 7.5 cms. in a neutral solution of $AgNO_3$.

The current from the 120 volt circuit was passed through about 70w so as to obtain approximately 2 ampères.

The deflections then obtained on the tangent scale were
0.411 clockwise and 0.411 counterclockwise.

At 9.40.00 the silver voltameter was brought in cct.
" 9.43.00 " " " " cut out.

The deflection during these 180 secs. was steady at 0.411 cct.

The weight of the cathode before was 17.690 gms after 18.112 gain 0.422
" " " " anode " " 17.808 " " 17.379 loss 0.429

Mean of gain and loss 426 mgms

4.26×10^{-4} gms / 1.80×10^{2} secs = 2.367×10^{-3} gms per sec.
$2.367 \times 10^{-3} \div 1.11815 \times 10^{-3}$ = 2.117 ampères.
$0.411 \div 2.117$ = 0.1942 Constant of Galvo.

Second trial

The same connections were used.

The deflections obtained were 0.410 very steady on each side.

At 10.44.00 the silver voltameter was brought in circuit
" 10.50.00 " " " " cut out of "

The weight of the cathode was 18.2205 and before 17.379 gain 0.8415
" " " anode " 17.2225 " " 18.112 loss 0.8895

a quantity of silver powder was noticed in washing the plates to fall from the anode. This was deposited silver that had evaporated reducing and thus was left as a fine powder without support.

Taking the gain as correct

8.415×10^{-4} gms $\div 3.60 \times 10^{2}$ secs = 2.3375×10^{-3} gms per sec.
$2.3375 \times 10^{-3} \div 1.11815 \times 10^{-3}$ = 2.090 ampères.
$0.410 \div 2.09$ = 0.1962 Constant of Galvo.

Taking mean we have 0.195 as the Constant.

With the ring tangent galvo in series with the Black ~~the~~ deflected steadily to 0.390 the deflection was 15°.15' clockwise and 15° 0' counterclockwise. Taking the mean as 15°.07' whose tangent = 0.27013 the tang. per amp: = 0.13507 or tan⁻¹ 7°.42'.

The two galvo: seems to exercise no appreciable influence on each other, as found

Meter Test.

The measurement of the res. of the bottles with 1.11 solution was repeated with neutral solution. The temperature of the bottles in the refrigerator was however not kept so low.

The test commenced at 13 o'clock on the 14th May, the current being 10 milliampères. In the refrigerator there were four bottles and in the warm box five. The results are shown in the following tables. The plates in the refrigerator were found to have slightly amitted.

No. of Plate	Weight 14th May	Weight of couple	Weight 17th May	Weight couple.	Gain:	Gain	Loss.	Acceptts	Mean temp	
1	116·962	231·919	117·256	231·896	−0·023	0·294				
2	114·957		114·640				0·317	0·317	10·3°	
3	125·835	240·145	125·500	240·148	+0·003		0·335			
4	114·310		114·648			0·338		0·336	"	
5	125·420	246·564	125·100	246·564	+0·010		0·320			
6	121·134		121·464			0·330		0·325	"	
7	116·434	235·694	115·861	235·696	+0·002		0·573			
8	119·260		119·835			0·575		0·574	"	
9	119·935	235·719	120·510	245·713	+0·006	0·575		0·578	34·5°	
10	125·784		125·203				0·581			
11	117·749	234·242	117·318	234·241	−0·001		0·431			
12	116·493		116·923			0·430		0·430	"	
13	116·074	241·470	115·655	241·480	+0·010		0·419			
14	125·396		125·825			0·429		0·424	"	
15	118·535	244·380	118·964	244·373	−0·007		0·436			
16	125·845		125·409			0·429		0·433	"	
17	126·884	253·702	127·463	253·710	+0·008	0·579				
18	126·818		126·247				0·571	0·575	"	
				Mean	−0·0002					

No. of plate	Res. of Shunt = 24·5°C	Res. of Sh. @ temp both sides	Fall Current weight	W − w	w	Res. bottle	Mean	Results by last trial	
1, 2	4·120	4·180		0·259	0·317	3·37ω			
3, 4	4·095	4·110		0·240	0·336	2·94ω	3·16ω @ 10·3°	3·76ω @ 4·5°	
5, 6	4·100	4·115		0·251	0·325	3·18			
7, 8	∞		0·576						
9, 10	∞								
11, 12	2·050	2·099		0·146	0·430	0·713			
13, 14	2·050	2·099		0·152	0·424	0·752	0·729	1·04ω	
15, 16	2·055	2·104		0·143	0·433	0·695	@ 34·5°	@ 32°	
17, 18	∞								

Temp: in refrigerator

4 hrs @ 58°F	=	232
7 - - 54°	=	378
2 - - 52	=	104
4 - - 50	=	200
2 - - 52	=	104
2 - - 48	=	96
7 - - 50	=	350
2 - - 50	=	100
15 - - 48	=	720
1 - - 48	=	48

Mean = 50·5°F
= 10·3°C.

Temp: in hot box.

2 hrs @ 88°F	=	176
2 - - 92	=	184
7 - - 94	=	658
2 - - 84	=	168
2 - - 90	=	180
2 - - 94	=	188
2 - - 88	=	176
9 - - 96	=	864
2 - - 86	=	172
2 - - 96	=	192
2 - - 98	=	196
2 - - 96	=	192
9 - - 98	=	882
2 - - 96	=	96

Mean = 94°F = 34·5°C.

Calculation of the res: of the meter resistance for Paris. Using the old bottle and solution (1.054). and assuming 1224 mgms of Zinc to the amp: hr.

With a shunt of 0.02 ω the res: in the bottle circuit has to be 24.46 ω when the current in the bottle will be $\frac{C \times 0.02}{24.46 + 0.02}$ or $\frac{1}{1224}$ C so that the desired relation is obtained.

The res: of the 1.054 bottle is taken as 2.36 ω @ 10°C
and 1.25 ω @ 25°C
a difference of 1.11 ω for 15°C.

$\therefore x(1.00388)^{15} - x = 1.11$

$\therefore$ $15 \times 0.0016818 = 0.02523 = \log^{-1} 1.0598$

$\frac{1.11}{0.0598} = 18.56$ ω @ 10°C. + 2.36 = 20.92 ω

18.56 ω @ 10° = 18.92 ω @ 15°C. + ~~2.36~~

18.92 ω + 1.77 = 20.69 + 3.77 = 24.46 ω required.

18.56 ω @ 10° = 19.67 @ 25° + 1.25 = 20.92 ω.

Take then 18.92 ω copper and 3.77 ω g.s.

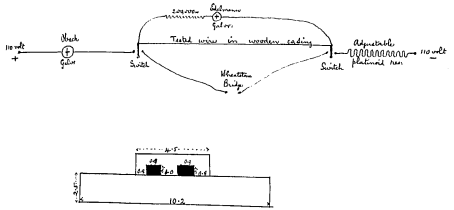
If the shunt resistance be 0.02 B.A. ohm, then the bottle will be 2.387 @ 10°
1.264 @ 25°
difference 1.123 for 15°

$\frac{1.123}{0.0598} = 18.78$ ω @ 10° + 2.387 = 21.167

18.78 @ 10° = 19.915 ω @ 15°

18.78 @ 10 = 19.9054 + 1.264 @ 25° = 21.167

Take then 19.15 ~~lg~~ ω of copper @ 15°
1.79 . . . bottle
3.52 . . . g.s.
21.46



Experiments on the Carrying power of Conductors:—

Took 24 ft samples of different sized covered wires to determine the rise in their temperature under certain conditions of environment and current. After several preliminary experiments the connections shewn on the opposite page were commenced with. Definite current strengths were passed through the wire for ten minutes at a time, the Edelmann Galvo observed with a telescope enabling an estimate to be formed of the permanent condition arrived. The switches were then thrown over and a bridge reading taken as quickly as possible afterwards.

The wooden lining was formed of a plank 20'4½" long 1" thick and 4" wide. On it was mounted a strip 1¾" wide ½" high and grooved with two parallel grooves ⅝" wide x ¼" high.

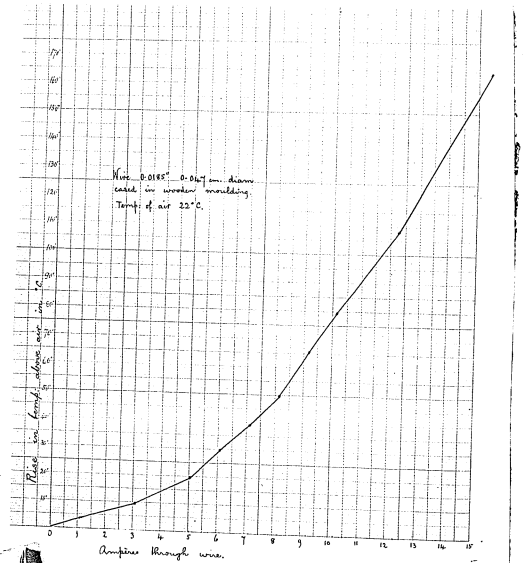
The first wire tried was marked grade 1 No 25 B.W.G.
The copper wire was 0·0185" diam = 0·01699 cms.
It was whipped with cotton to 0·024" = 0·06 "
and braided - 0·110" = 0·279 cms.
The tabular res: of this wire being 0·0259 ω per foot 20 ft = 0·516 ω.
Its length was 612 cms. and its res: @ 22°C was
by one measurement 0·5875 @ 25·5°C
0·588 @ 22°C. but

After the measurements were made, a test was taken to determine the coeff. for temp. @ follows:— The wire was coiled up and placed in a porcelain dish containing boiled linseed oil the dish was heated to 320°F and on cooling, the temperatures were observed and corresponding resistances obtained, while the oil was well stirred.

No of Obs.	Temp: Bath °F	Temp: Bath °C	Res: dish heads	Res: of wire	$(\frac{R}{r})^{\frac{1}{t}}$	log $\frac{R}{r}$	$\frac{1}{t}$ log $\frac{R}{r}$	1+x	x	R @ 0°C
1	72°F	22°	0·7420	0·5750 ω	0·588 ω					
2	310°	154·5	1·019	0·865	1·471	0·16761	0·001265	1·0026	0·26%	
3	300°	148·9	1·006	0·852	1·449	0·16107	0·001268	1·0026		
4	290°	143·3	0·998	0·844	1·435	0·15685	0·001293	1·0030	0·30%	
5	280°	137·8	0·982	0·830	1·412	0·14983	0·001294	1·0030		
6	270°	132	0·972	0·818	1·391	0·14333	0·001303	1·0030		
7	260°	126·7	0·963	0·809	1·376	0·13862	0·001324	1·0035	0·35%	
8	250°	121	0·950	0·796	1·354	0·13162	0·001330	1·0037	0·37%	0·5498
9	200°	93·3	0·8845	0·7305	1·242	0·09412	0·001320	1·0035	0·35%	
10	70°	21·1	0·739	0·585						

The sp: res: = $\frac{0·5498 \times 10^3 \times 0·001735}{612}$

$\frac{5·498 \times 1·735}{6·12} \times 10^3 = 1560$



On the carrying power of Conductors.

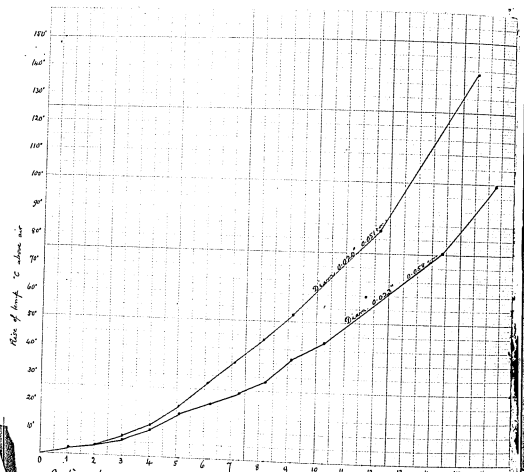
May 20th Monday.

No 1 Conductor

No. of Obs.	Time	Black Mean Deflec.	Current amperes	Temp. air.	Res. std.	Leads.	Res. wire.	$\frac{R}{r}$ (0·001393)	$\log \frac{R}{r}$	$\log \frac{R}{r}$ / $\log 1{\cdot}0034$	Rise of temp. °C.		T.B.
1	9.20	0	0	25·2°C	1·5660	0·9785	0·5875						26°
2	10.$\frac{0}{10}$ $\frac{0}{10}$	0·6	3·077		1·580	0·980	0·600 ?	1·021	0·009021	6·79	6·9	5·5	
3	10.$\frac{16}{32}$	1·00	5·128		1·623	0·980	0·643	1·094	0·039017	29·3	29	24·8	
4	10.$\frac{32}{32}$	1·212	6·214		1·673	"	0·693	1·180	0·071882	52·0	54	47·5	
5	10 $\frac{40}{40}$	0·695×2	7·126		1·669		0·689	1·173	0·069298	52·1	52	45·5	
6	11.$\frac{12}{40}$	0·710×2	7·282		1·670		0·690	1·17745	0·069185	52·5	52·5	46	
7	11.$\frac{27}{40}$	0·783×2	8·03		1·690	0·981	0·709	1·207	0·08171	61·4	61·5	54·5	
8	11 $\frac{34}{40}$	0·911×2	9·344		1·720 *		0·739	1·258	0·09964	74·9	75	68·0	
9	11.$\frac{48}{40}$	1·05×2	10·256		1·745		0·764	1·301	0·11428	85·9	86	79·5	
10	11.$\frac{53}{40}$	0·800×3	12·430		1·840		0·859	1·462	0·16495	124·0	124	124	
11	11.$\frac{53}{40}$	0·992×3	15·29		2·00	0·982	1·018	1·733	0·23880	179·5	179·5	193	23°

Some of these readings were very accurate partly from want of practice. The observation #8 marked with an asterisk was the first at which the two switches were turned simultaneously thus enabling the reading to be taken with less loss of time. The following set is much more reliable and is fairly accurate.

No. of Obs.	Time	Black Mean Deflec.	Current amperes	Temp. air	Res. std.	Leads.	Res. wire.	$\frac{R}{r}$ (0·001393)	$\log \frac{R}{r}$	$\log \frac{R}{r}$ / $\log 1{\cdot}0034$	Rise of temp. °C.		T.B.
1	13.27	0	0	26·7°	1·5695	0·978	0·5905						23°
2	13.$\frac{27}{40}$ $\frac{27}{40}$	0·2095	1·074		1·573		0·595	1·013	0·00561	3·34	3·3	3·4	
3	14.$\frac{12}{40}$	0·598	3·067		1·587		0·609	1·037	0·01578	9·38	9·4	9·7	
4	14.$\frac{24}{40}$	0·984	5·047		1·612		0·634	1·079	0·03302	19·64	19·6	22·9	
5	14.$\frac{40}{40}$	0·801×2	6·164		1·6375		0·6395	1·122	0·04997	29·73	29·7	32·0	
6	14.$\frac{55}{40}$ $\frac{55}{40}$	0·701×2	7·190	24·4	1·665	0·9815	0·6835	1·163	0·06558	39·0	39	42·8	
7	15.$\frac{14}{40}$	0·789×2	8·194		1·694		0·7125	1·213	0·08386	49·87	49·9	55·9	
8	15.$\frac{30}{40}$	0·901×2	9·240		1·7285		0·7570	1·288	0·10992	65·34	65·4	75·7	
9	15.$\frac{50}{40}$	0·995×2	10·205		1·7714		0·7935	1·349	0·13033	79·12	79·1	91·7	
10	15.$\frac{56}{40}$	0·799×3	12·295		1·8714		0·8925	1·519	0·18156	108	108	126·2	
11	16.$\frac{10}{40}$ $\frac{10}{40}$	1·004×3	15·450	22· 22·	2·0885	0·9815	1·1070 0·5875 Standard.	1·884	0·27548	163·6	163·6	232·	33°



Measurements of Heating of Current-carrying conductors.

(18)

May 21st Tuesday.

#2 Conductor tested marked #25 B&S gauge

Micrometer measurement gave diameter 0·020" = 0·0508 cms.
whipped to - 0·051
braided to - 0·100" = 0·254 -

Length 612 cms measured in moulding as before.

No. of Obs.	Time	Mean clock Deflection	Current amperes	Temp. air	Res. std.	Leads.	Res. wire	$\frac{R}{r}$ 0·003938	$\log\frac{R}{r}$	$\log\frac{R}{r}$ $\log 1{\cdot}00338$ 0·006816	Rise in temp. above air		Temp. Bridge
1	9.37	0	0	19.8°	0.8865	0.377	0.5095						19.8°
2	9.45	0.210	1.077		0.891		0.5114	1.009	0.00389	2.31	2.3	2.32	
3	9.52	0.396	2.031		0.894		0.517	1.015	0.00647	3.85	3.9	3.94	
4	10.15	0.598	3.067		0.9012		0.5212	1.029	0.01242	7.39	7.4	7.5	
5	10.35	0.794	4.072		0.909	0.376	0.533	1.0466	0.01953	11.62	11.6	11.9	
6	10.55	0.995	5.103		0.9235		0.5475	1.075	0.03141	18.68	18.7	19.4	
7	10.35	0.895×2	6.119		0.9420		0.5662	1.111	0.04571	27.18	27.2	28.6	
8	10.55	0.695×2	7.118		0.959		0.583	1.1454	0.05843	34.75	34.8	37.2	
9	11.25	0.797×2	8.174		0.9783		0.6023	1.182	0.07262	43.18	43.2	47.0	
10	11.40	0.895×2	9.20		1.001	0.3765	0.6245	1.226	0.08849	52.63	52.6	58.5	
11	11.55	1.097×2	10.33		1.0085	0.3	0.6220	1.2241	0.09377	55.77	55.8	62.2	
12	11.35	0.796×3	12.155		1.079		0.7025	1.379	0.13956	83.0	83.0	98.0	
13	11.55	1.011×3	15.55		1.250	0.3775	0.8725	1.712	0.23350	138.9	138.9	134.6	21.9°

#3 Conductor tested marked #23 B&S

Micrometer measurement gave diameter 0·023" = 0·0584
whipped to - 0·050" =
braided - - 0·120" = 0·3048

Length 612 cms measured in moulding as above.
The bridge used in this test was the Hartmann & Braun wire bridge, together with the 0·10 ω standard coil.

No. of Obs.	Time	Mean clock Deflection	Current Amperes	Temp. air	Bridge Reading	Amperes	Res.	Leads.	Res. wire	$\frac{R}{r}$	$\log\frac{R}{r}$ 0·003816	$\log\frac{R}{r}$ $\log 1{\cdot}00338$ 0·006816	Rise in temp. above air	Temp. Bridge
1	15.20	0	0	22.°C	0.396	0.604		0.0656						22.2
2	15.20	0	0		0.407	0.193	0.41892		0.3526					
3	15.30	0.210	1.077		0.408	0.192	0.4209		0.3553	1.008	0.00346	2.06	2.1	2.1
4	15.35	0.400	2.051		0.409	0.191	0.4236		0.3580	1.015	0.00647	3.85	3.9	3.9
5	16.45	0.591	3.031		0.410	0.190	0.4263		0.3607	1.023	0.01088	5.88	5.9	6.0
6	16.55	0.797	4.087		0.412	0.188	0.4320		0.3664	1.039	0.01662	9.88	9.9	10.1
7	16.55	1.002	5.137		0.415	0.185	0.4406		0.3750	1.064	0.02691	16.02	16.0	16.6
8	16.25	0.607×2	6.245		0.417	0.183	0.4465	0.3915/cm = 0.1556	0.3809	1.080	0.03312	19.97	19.9	20.9
9	16.35	0.713×2	7.312		0.419	0.181	0.4525		0.3869	1.097	0.04021	23.91	23.9	25.4
10	16.45	0.815×2	8.220		0.421	0.179	0.4588		0.3932	1.115	0.04737	28.11	28.1	30.0
11	17.55	0.893×2	9.158		0.425	0.175	0.4715		0.4059	1.151	0.06108	36.33	36.3	39.2
12	17.45	1.093×2	10.29		0.428	0.172	0.4815		0.4159	1.180	0.07188	42.75	42.7	46.9
13	17.35	0.796×3	11.73		0.436	0.164	0.5097		0.4441	1.260	0.10037	59.68	59.7	65.5
14	17.35	0.956×3	14.40		0.445	0.155	0.5452		0.4796	1.360	0.13351	79.84	79.8	93.5
15	17.25	0.997×4	16.35		0.454	0.146	0.5850		0.5192	1.470	0.16732	99.50	99.5	122.
16			0	22.°C.	0.400	0.600		0.0667						

May 22nd Wednesday.

Determination of constant of Siemens' Dynamometer thin wire coil.

Weighed plates of Silver Voltameter No 1. 17.221 } 35.4345
·2 18.2135
Pair 35.4345

17. 16. 30 Current on. through Voltameter.
Dynamometer reading 122°·20'. steady
Obach Ring - 0.920 × 2 →

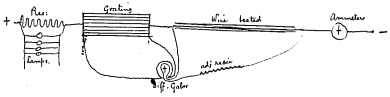
The strength of this current was too great for the voltameter which quickly assumed a spongy mass of bore deposited silver on the cathode. Probably therefore the current density should not exceed 0·1 amp. per sq. cm in order to obtain a good deposit.

17. 18. 20 Current off.
Time 110 seconds. Weight of plate no 1. 16.05 95 } 34.8315
- - - - 2 18.772
Pair 34.8315

Gain of no 2 0.5585 quite valuable
Loss - - 1 1.1615 gm.
Loss per sec. 0.01056 gm
Current 9.442 ampere.
Obach const. 0.1949 per amp.
$\sqrt{122.5}$ = 11.068
Dynamometer Const 0.8530 against tabular value 0.928
On the 16th May 88 the constant was calculated to be 0.857 $\sqrt{\tan}$
" " 12th Sept " - - - - - 0.862 $\sqrt{\tan}$

Took over comparison of deflections with Obach and the long Ammeter

Mean Obach reading 0·890 × 2 = 1·78 / 0.195 = 9·13 amp.
produced 0·5 deflection at mean dist. of 11·78 cm.
$11.78^2 = 138.77 + 36 = (174.77)^{\frac{1}{2}} \div 226.2 \times 1.89 = 19.204 \div 2 = 9.652.$
gave a reading consequently some 5% in excess.



Heating of Conductors.

May 23rd Thursday

Wire marked #21 B.W.G. Diam: by micrometer 0·0315" = 0·0800 cms
#4 Conductor. whipped to 0·045"
braided - 0·120" = 0·305 -

No. of Obs.	Time	Mean Mark Deflen.	Amperes	Mean Sum of Degrees Deflen. with Rdg.	Amperes	Mean Sum of Degrees Deflen. without Rdg.	Const.	Amplified Amperes	Bridge	0·1 ohm 90 Reading	Res. of Coil	Resist.	Res. of wire	$\frac{R}{r}$	$\log \frac{R}{r}$	$\log \frac{R}{r}$ POWER	Temp. cen. °C
1	9·45	0·000		74·5°					322	608		0·0645					
2	9·55	0·040	2·051	87·5°	2·34			2·051	1722	273	0·2636		0·1991	1·000			17·5°
3	9·55	0·805	4·128	25·3	4·29			4·128	728	272	0·2677		0·2072	1·021	0·00931	5·37	26·0
4	9·55	0·2999	6·143	26·3	5·81			6·14	732	268	0·2731		0·2084	1·028	0·02256	12·11	111·103
5	9·55	0·8202	8·221	93°	8·23			9·22	733	267	0·2745		0·2100	1·055	0·02327	13·93	117·121
6	9·55	0·9900	10·20	149·5°	10·15			10·20	739	261	0·2832		0·2187	1·099	0·04100	24·38	256·256
7	9·55	1·2002	12·31	214·5°	12·148	19°	2·82	12·31	746	254	0·2937		0·2282	1·146	0·05918	35·2	35·374
8	9·55	1·4832	14·44	308°	14·99	29·4	2·66	14·44	754	246	0·3066		0·2381	1·216	0·07493	50·5	50·583
9	10·05	0·0002	16·41	—		37·3	2·69	16·41	762	238	0·3202		0·2557	1·284	0·10857	64·25	64 72·8
10	10·25	0·9992	18·42			46·	2·72	18·42	771	229	0·3367		0·2722	1·367	0·13577	80·74	80 94
11	10·45	0·9972	20·25			54·2°	2·752	20·25	780	220	0·3546		0·2901	1·457	0·16346	97·2	96·117
12	10·55	1·1074	22·56			71·5°	2·666	22·56	792	208	0·3808		0·3163	1·589	0·20112	119·6	118 151
13									810	190	0·4263		0·3619	1·817	0·25935	154·2	152·209
									392	608		0·0645					19°

May 24th Friday

Brought into use a platinoid grating of forty wires 0·031" diam each 2·44 cms long approximately 2 ohms so that the resistance of the set is approx 0·05Ω. A preliminary test of this made the res: $\frac{2630}{2630 + 2672} = 0·0495$ @ 20·0°C. the two halves of this res: offered $\frac{2630}{6500 + 2670} = 0·0287\Omega$.
The Res: of the diff: galv: was as follows. Rt: hand coils 2671·5Ω mean @ 20·7°C.
Temp: galv: 20·2°C. Lft - - 2628·5 - - -

Wire tested diam: by micrometer 0·0446" = 0·112
#5 Conductor whipped to 0·070".
braided - 0·130" = 0·330

No. of Obs.	Time	Mean Mark Deflen.	Amperes	Mean Sum of Degrees Deflen. with Rdg.	Amperes	Mean Sum of Degrees Deflen. without Rdg.	Const.	Amplified Amperes	Res. in cat:	Ratio	Res. of wire	$\frac{R}{r}$ 0·001562	$\log \frac{R}{r}$	$\log \frac{R}{r}$ 0·00168	Rise in temp. above air	Temp. cen.
1	15·45	0·20	1·0						3270	306	0·1130					
2	15·55	0·1403	2·07			22°			3290	2·269	0·1134	1·003	0·00130	1·0	1·0	20·8°
3	15·55	0·807	4·14						3310	2·276	0·1188	1·007	0·00303	1·80	1·8	19
4	16·05	1·644	8·23			8°			3450	2·329	0·1165	1·031	0·01326	7·88	7·9	30
5	16·25	1·922	10·16			19·7			3555	2·369	0·1155	1·046	0·02078	12·36	12·4	37
6	16·35	2·404	12·33			20			3720	2·431	0·1286	1·076	0·03181	18·92	18·9	47·6
7	16·35	2·816	14·44			30			3890	2·495	0·1288	1·105	0·04336	25·79	25·8	57·2
8	16·55	3·220	16·51			38			4095	2·575	0·1289	1·140	0·05690	33·84	33·8	64·2
9	16·55	3·600	18·46			45·2			4260	2·635	0·1338	1·184	0·07335	43·61	43·6	67·6
10	17·05	4·000	20·51			69			4490	2·797	0·1399	1·238	0·09272	55·13	55·1	69·5
11	17·05	4·406	22·60			67·5			5015	2·924	0·1461	1·294	0·11193	66·56	66·6	76·0
12	17·35	4·805	24·64			87·5			5370	3·060	0·1530	1·354	0·13162	78·26	78·3	91·5
13	17·45	5·210	26·72			92°			5835	3·235	0·1618	1·432	0·15594	92·72	92·7	117°
14	17·55	5·644	28·95			105°			6480	3·481	0·1740	1·540	0·19722	117·5	117·5	20·8°
15																

Results of Storage Cell test.

Mean EMF for 11 hours	2·023 volts.
" P.D. at terminals	1·923 "
Int: res: discharging	0·005 ohms
" Current	14·9 ampères.
" Ampère hours	164 for 11 hrs.
" Watts out: energy	29·6
" Total Energy out	325·3 watt hours = 1,170,000 Joules
" No. of cells per H.P.	25·2 = 355 foot-lbs
" Weight of cells per HP	1160 lbs or 2 H.P. per ton (approx)
" Watts per lb. of cell out	0·64.

Test of a Storage Cell.

Received on May 22nd a storage cell manufactured by the Anglo-American Electric Light Manufg Co.

Its weight was 38·5 lbs. = 17·46 kilos when charged in all 46 lbs = 20·9 kilos

There were 4 + and 4 − plates, each {15·5 × 15·5 × 1·3 thick / 6⅛" × 6⅛" × ½"}

The area of each face {240 sq. cms / 37¼ sq. ins} so that the total active area = {3360 sq. cms / 522·5 sq. ins} on both sides

The separating distance between the plates = {0·7 cms / 1/4 in} or on each side {1680 sq. cms / 261 sq. ins}

The whole set of plates formed almost a perfect cube.

The plates were formed of lead strip 0·2 cm thick bent into regular loops ~~ecco~~ so that a large volume of material could be enclosed.

The solution was supplied with the cell. it is stated to consist of a mixture of pure H_2SO_4 and H_2O about 20% and sp.g. 1·18 g at normal temp. Its actual sp.g. was 1·195. The quantity of solution was 2500 c.c. The nominal capacity of the cell was 150 ampère-hours. Instructions were received from Mr Wirt to charge it to the extent of 300 ampère hours at rate of 20 for 15 hrs, then discharge it at rate of 15 till 1·75 volts was reached.

Commenced charging		10·15	24. 5. 89	Stopped 12 – 13
Stopped	-	1	25. 5. 89	
Recommenced	-	8·15	- -	
Stopped	-	9·30	- -	

Total time 15 hours. @ 20 ampères from 100 volt cct and lamp-tank.

At 9·0 ~~the~~ 25. 5. 89 the P.D. on the terminals while charging was 2·488 and when current of 20 ampères interrupted 2·260

Diff 0·128/20 = 0·0064 ω internal resis:

Density of charging current 0·012 amp per sq. cm.

The EMF after charging was 2·228 volts.

No. of Obs.	Time	EMF	P.D.	P.D. on 0·01	Current	Diff.	I.R.	Time of Disch.
1	10·20	2·136	2·054	0·081	16·0	0·052	0·0051	0
2	12·0	2·096	2·038	0·083	16·2	0·058	0·00358	1½
3	15·45	2·028	1·944	0·075	15·0	0·084	0·0056	5¼
4	16·30	2·024	1·936	0·075	15·0	0·088	0·0059	6
5	20·00	1·970	1·897	0·071	14·2	0·073	0·0051	9½
6	21·00	1·941	1·821	0·064	12·8	0·120	0·0094	10½
7	22·00	1·810	0·600	0·041	8·2	1·210	0·149	11½
	Ampère hours by acc.		1½ @ 16·2	= 24·3				
			4½ @ 15·2	= 68·4				
			3½ @ 14·5	= 50·8				
			1 @ 13·5	= 13·5				
			1 @ 10.	= 10				
			11½	167·0				

The cell was discharged through Standard Edison meter #10998 and the Ampère which coincidente distinctly, also the Standard 0·01 ω.

The weight of the plates at 9·0 o'clock was no 1 113·346 no 2 121·9234

" " " " " " 22·30 " " " 113·5488 " " 121·7145

+ 0·2035 − 0·2095

Mean 0·206

0·206 in the bottle cct is equivalent to 206 gms in shunt cct

$\frac{206}{1·224}$ = 168·3 ampère-hours.

2629 = @ 15·5 & 18 = 2·5° C @ 0·388% = 0·97% = 26 excess
= 2655 ω.

Carrying Capacity of Conductors.

Sunday 26th May

Compensated the error of magnetic influence + res: in the Edelmann differential galv: Residual differential error quite negligible and compound coils of equal resistance to 1ω.

27th May Monday

Measured more accurately the res: of the platinoid grid.

Res: of galv. 5263 or 2631·5 in each coil T.B. 15·8 = 3° from std temp.
= ·03 % = 2·4 — or 2629 ω

Res: in cct: with 0·1ω @ 15·5° C 2752 ω = about 2750.

Res: of std: @ 17·2° 0·10022 ω @ 15·5 = 1·7° × ·02 % = ·034% = 0·10025 ω.

" " grid = $\frac{2625}{2750 + 2629}$ × 0·10025 = 0·04899 ω @ 15° C.

Compared the two halves. found balance at 10 amperes with 7ω added to the one both side

or x : 0·04899 − x :: 2636 : 2629 whence x = 0·02453 ω } @ 15° C.
2 both sides = 0·02446 ω

Wire tested as follows:—

Diameter 0·051" = 0·1295 cm

#6 whipped to 0·075"
brazed to 0·120 = 0·305 cm.

No of obs	Time	Mean Steel Deflec.	Amperes	Specific Dynes Shunt cct	Resistance	Temp 84 Res added to wire cct.	Ratio of wire	Ratio $\frac{R}{r}$	log $\frac{R}{r}$	log $\frac{R}{r}$ / 0·006818	Rise in temp. above air °C	Temp. air
1	13·40	0·222			1588		0·0776					18·2°
2	13 $\frac{55}{60}$	0·899	2·046	"	1565		0·0779	1·0024	0·00173	1·03	1	
3	13 $\frac{58}{60}$	1·004	5·169		1605		0·0786	1·013	0·0561	3·34	3·3	
4	14 $\frac{55}{60}$	1·610	8·256	10°	1670		0·07933	1·029	0·02242	7·38	7·4	
5	14 $\frac{55}{60}$	2·038	10·45	16	1730		0·07996	1·043	0·01828	10·88	10·9	
6	14 $\frac{55}{60}$	2·398	12·30	22	1805		0·08232	1·061	0·02572	15·29	15·3	
7	14 $\frac{55}{60}$	2·804	14·38		1920		0·08444	1·088	0·03663	21·78	21·8	
8	14 $\frac{55}{60}$	3·221	16·46	36	2·743	2025	0·08640	1·113	0·04650	27.65	27·7	
9	15 $\frac{5}{60}$	4·020	20·62	51	2·889	2295	0·09139	1·178	0·07115	42·31	42·3	
10	15 $\frac{55}{60}$	4·384	22·49	59·5	2·918	2465	0·09352	1·218	0·08565	50·93	50·9	
11	15 $\frac{55}{60}$	4·808	24·66	82	2·722	2680	0·09850	1·269	0·10346	61·51	61·5	
12	15 $\frac{55}{60}$	5·240	26·87	99·5	2·695	2987	0·10868	1·341	0·12743	75·79	75·8	
13	15 $\frac{55}{60}$	5·621	28·87	115	2·698	3260	0·1192	1·407	0·14829	88·18	88·2	
14	15 $\frac{55}{60}$	6·012	30·82	125·5	2·724	3522	0·1260	1·469	0·16702	99·32	99·3	
15	16 $\frac{25}{60}$	6·396	32·80	143	2·733	3800	0·1391	1·535	0·18611	110·66	110·7	
16	16 $\frac{55}{60}$	6·796	34·86	163·5	2·724	4215	0·1268	1·631	0·21325	126·83	126·8	20·5°

Specific res: as follows:—

Balance @ 15° air $\frac{4129}{2629}$ × 0·029 ω. = 0·07712 ω.

log $r_{(0)}$ = log ·07712 − 15 log 1·00388
= −2·88717 − 0·02523 = 3·86194.

r = 0·07277 ω.

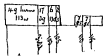
sp. res. = 0·07277 × 0·01317 × 10^3/612 = $\frac{7.277 \times 1.317}{6.12} \times 10^3$ = 1567 = 101·1%

Particulars of Phonograph Motor wound for Electric Light ccts.

May 27th + 28th

Tested two machines from the phonograph factory

The field cct: measures about 170 ω wound with no. 30 copper wire d.c.
" armature " " " 30 ω " " " 35 " " "
" res: in cct: with the machine was experimentally determined to be 65'.4" of no 30 platinoid B.W.G 0.012" offering 1.82 ω per foot.
Wound on a spool of 16" to the turn and 8 turns to the inch gave



4 avg turns of 113 ω res. to the field magnets and an additional

17 turns or	82'.6"	to	100 volts armature cct	=	39 ω extra or	152 ω in all
6 " or	90'.	"	105 "	"	" = 13.5 ω	" " 165.5 " "
6 " "	97'.6"	"	110 "	"	" = 13.5 ω	" " 179 " "
6 " "	105'.0"	"	115 "	"	" = 13.5 ω	" " 192.5 " "
Total = 84	" "		105.0			192.5 " "

In work this wire becomes appreciably warm.

The current in the armature cct: was 0.36 amp: stipped volts 12.6
" " " " field " " 0.32 " running " 19.5
" " " " field " " 0.25 "

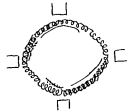
so that the total current running is 0.57 amp. × 110 volts = 62 Watts.

19.5 − 10.7 = 8.8 volts the counter e.m.f of the machine at about 170 revs: per min:

The res: necessary to control the spark in governing was about 60 ω, less than this made the governor useless, but even at 60 ω there was too much sparking.

A small condenser about 0.03 μf was apparently more efficacious.

On the conversion of the multipolar dynamo into an alternating-current machine



By reversing the windings as many times in the circle as there are poles to the machine, the maximum e.m.f. would be the present constant e.m.f. in each sector. and the mean alty. emf would be $\frac{2}{\pi}$ time this or the present emf say 140 volt × 0.6366 = 89 × 8 = 712

There would be 8 alternations or 4 complete periods per rev:
$= \frac{6400}{60} = 107$ alternations 53.5 complete periods per sec: @ 800 revs:

Carrying Capacity of Conductors.

87 Wire tested Kenite No 14 B.W.G. 0·064" = 0·163 cms.
covered to 0·210" = 0·533 "

Potentiometer in cct with the wire hooks. Half of grid = 0·02445 v. Res. Galv 2660 ω. 17°C.

No. of Obs.	Time	Clock	Siemens	Potentiometer Rdg	Clock Const.	Siemens Const.	Mean Potentiometer Rdg	Amperes	Res. in cct with wire	Total res. in wire cct	r_{mg} δ	Max. of wire
1	9·10	0·2		0·0105					250	2890	1·095	0·05362
2	9·$\frac{10}{20}$	0·8	1·5	0·0495	0·288	$\frac{2·295}{2·583}$	0·0269	4·00	260	2900	1·099	0·05874
3	·$\frac{55}{20}$	1·6 (a)	8°	0·103	0·1903	$\frac{2·297}{2·486}$	0·1029	9·40	287	2927	1·109	0·05717
4	$\frac{55}{20}$	2·0 (a)	12·5°	0·130	0·1885	$\frac{2·337}{2·526}$	0·1301	10·62	307	2947	1·116	0·05705
5	·$\frac{55}{20}$	2·4 (a)	17°	0·1508	0·1950	$\frac{2·35}{2·545}$	0·1561	12·74	330	2977	1·128	0·05719
6	·$\frac{55}{20}$	3·01 (a)	33°	0·1978	0·1864	$\frac{2·41}{2·596}$	0·2000	16·33	380	3020	1·1144	0·05734
7	·$\frac{55}{20}$	3·60 (b)	38°	0·2328	0·1895	$\frac{2·405}{2·595}$	0·2351	19·19	?			
8	·$\frac{55}{20}$	4·40 (b)	54°	0·2816	0·1914	$\frac{2·43}{2·627}$	0·2805	22·90	535	3175	1·203	0·06273
9	·$\frac{55}{20}$	4·80 (b)	76·5°	0·3204	0·1836	$\frac{2·454}{2·637}$	0·3208	26·19	565	3205	1·2114	0·06451
10	10·$\frac{55}{20}$	4·96 (a)	92°	0·3304	0·1864	$\frac{2·49}{2·676}$?	0·3311	27·03	625	3365	1·275	0·06838
11	11·$\frac{55}{20}$	5·92 (a)	103·5°	0·3964	0·1830	$\frac{2·515}{2·698}$	0·3973	32·43	822	3462	1·311	0·07020
12	11·$\frac{55}{20}$	6·88 (a)	158°	0·4705	0·1793	$\frac{2·55}{2·729}$	0·4746	38·75	1125	3765	1·4226	0·07648
13	11·$\frac{55}{20}$	7·92 (a)	212°	0·5473	0·1773	$\frac{2·587}{2·764}$	0·5439	44·40	1460	4100	1·553	0·07330
14	11·$\frac{55}{20}$	8·92 (a)	269°	0·6159	0·1774	$\frac{2·627}{2·804}$	0·6142	50·14	1900	4540	1·720	0·09224
						3·084						

No. of Obs.	$\frac{R}{r}$	log $\frac{R}{r}$	log $\frac{R}{r}$ / 0·006810	No. of log. of Temp.	Temp: air	No. of °C. wire, cell for change in temp	log r_{mg} − log 1·0485	r_{20}	$r \times \frac{0·00393}{612}$	$\frac{\delta}{r}$ per °C	$\frac{\delta}{r}$ Cmds	
1	1				17°		2·70092	0·05032	1655			
2	1·002	0·00173	1·029	1		1			$\frac{50000 \times 0·0000}{6·26·10^{-4}}$	2 1·095	17·40	
3	1·013	0·00561	3·336	3·3		3·3						
4	1·0195	0·00839	4·989	5		5						
5	1·030	0·01284	7·64	7·6		7						
6	1·0445	0·01912	11·37	11·4		10						
7	1·099											
8	1·099	0·04100	24·38	24·4		24						
9	1·109	0·04493	26·72	26·7		25						
10	1·165	0·06633	39·45	39·5		37·5						
11	1·197	0·07807	46·44	46·4		44·4						
12	1·302	0·11461	68·14	68·1		66						
13	1·419	0·15198	90·38	90·4		88						
14	1·571	0·19616	116·7	116·7		113·2						
					20·5°							

On the ratio between the wave lengths recognisable by the bolometer and those ~~producable~~ capable of being produced electrically.

The greatest wave-length yet appreciated by Langley's bolometer is stated by him as 30 μ = 300,000 tenth metre = $3·0 \times 10^{-5}$ cms.

The period of the shortest wave length hitherto electrically excited is given by Hertz Lodge + Rowland as the $1·0 \times 10^{-9}$ sec.

The corresponding wave-length = $\frac{3·0 \times 10^{10}}{1·0 \times 10^{9}}$ = 3×10^{1}

The ratio between these is thus 10^{6}

For mean visible rays it is $5·0 \times 10^{-5}$ and 3×10^{1} = $0·6 \times 10^{7}$ = $6·0 \times 10^{6}$

Carrying Power of Conductors.

May 20th Thursday

For Wire tested #16 B.W.G. Magnet wire 618 cms long) diam 0.064" = 0.162 cms
corrected to 0.055" = 0.216

Resr. of rock init. galv. 2.657

Ref. No.	Time	Clock	Bordat	Galvanometer Reading: Swinging down	Galvanometer Reading: Equilibrium	Potentiometer Rdg.	Amperes	Mean Potentiometer Reading	Amperes	Resr. in ckt. with wire	Total Resr. on wire side
1	11.30	0.2.			2.87				1	70	2727
2	35/20	0792	0.195	2°	2.62 / 3.4884	0.0297	1.058	0.0296	4.05	102	2759
3	40/20	1.0598 (1)	0.193	10°	2.62 / 3.6916	0.1016	8.294	0.1029	8.6[illegible]	140	2797
4	50/20	2.38 (1)	0.178	24°	2.72 / 3.673	0.1634	13.34	0.1638	13.37	217	2874
5	55/20	3.28 (1)	0.183	41°	2.81 / 3.635	0.2198	17.94	0.2284	18.65	325	2982
6	10/20	4.06 (1)	0.177	59.75°	2.91 / 3.866	0.2814	22.97	0.2755	22.49	465	3122
7	35/20	4.74 (1)	0.180	79°	2.94 / 3.885	0.3218	26.27	0.3216	26.26	635	3292
8	50/20	5.56 (1)	0.178	109.5°	2.99 / 3.944	0.3835	31.31	0.3839	31.34	850	3507
9	40/20	6.45 (1)	0.175	150°	3.01 / 3.924	0.4522	36.92	0.4545	37.10	1212	3869
10	50/10 min	7.24 (1)	0.175	178°	3.10 / 3.230 ?	0.5067	41.36	0.5079	41.47	1510	4167
11	55/20	7.94 (1)	0.172	219°	3.13 / 3.203	0.5658	46.20	0.5666	46.26	1915	4572
12	55/20	8.78 (1)	0.171	276.7°	3.19 / 3.240	0.6276	51.24	0.6313	51.54	2430	5087
					Mean 3.08			0.6310	51.51	2467	5117

Ref. No.	Res. of wire	$\frac{R}{r}$	log $\frac{R}{r}$	$\frac{\log R/r}{0.0016818}$	W. of Rise	Temp. air	Rise ckt. for change of air temp.	log r_0 −18 log 1.00138	r_0	$\frac{I \times 0.02096}{618}$	% Bord.
1	0.05030					18°C.		[illegible]	0.046944	15844	100%
2	0.05069	1.0120	0.00518	3.08	3.1		− 3.1	2.67130			
3	0.05158	1.025	0.01072	6.37	6.4		6.4				
4	0.0530	1.0537	0.02268	13.49	13.5		13.10				
5	0.0550	1.0934	0.03878	23.06	23.1		22.5				
6	0.05759	1.1448	0.05873	34.92	34.9		34.4				
7	0.06072	1.2072	0.08178	48.63	48.6		48.0				
8	0.06468	1.2860	0.10934	64.94	64.9		64.3				
9	0.07136	1.4190	0.15198	90.37	90.4		89.7				
10	0.07685	1.5280	0.18412	109.5	109.5		108.6				
11	0.08432	1.6760	0.22427	133.4	133.4		132.6				
12	0.09302	1.8650	0.27068	160.9	161.		160.				
13	0.09436	1.876	0.27323	161.3	161.3	19.5°	160.3				

A test was made of the comparison of two phonograph motor armatures one made up of soft iron plates in the usual way, the other of cast iron entirely.

When both armatures in series with 100 volt ckt. and res. the wrought iron ran 50% faster than the other, the machines and governors being disconnected.

When machine at work taking chip with battery

Current on wrought iron arm: machine 3.5 amp 1.6 volt = 5.6 Watts

" " cast " " 3.8 " 1.55 " = 5.9 "

This was owing to the shrinkage of the cast iron distinctly more chamm with it than with the wrought iron. Probably 50% more, and this it was estimated amply accounted for the deficiency here shown

Carrying Power of Conductors.

Wire tested 618 cms of # 14 B.W.G. black magnet wire diam = 0.2108
Day 31st Friday. Resistance 2.671 Rec. Galv. 2.658 Amp. 2660 19.4° density covered 6 0.102 " = 0.259
length 618 cms. between connection.

No. of Obs.	Time	Shock Rdg.	Const.	Sensitive Dipm. Rdg.	Const.	Long Range Ammeter	Potentiometer Rdg.	Amperes	Mean Potentiometer reading	Amperes	Res. in cats with grading
1	9.40	0.2					0.0102	0.829			1600
2	10/50	0.800	0.1995	5.5°	1.7		0.0293	4.009	0.0290	3.904	1580
3	20/75-10	1.606 (1)	0.1976	7.25°	3.58'		0.1000	8.13	0.1019	8.284	1540
4	20/70	2.450 (2)	0.191	20.5°	3.58 ?		0.1580	12.85	0.1577	12.82	1485
5	18/50	3.190 (3)	0.188	34.5°	2.89		0.2082	16.93	0.2091	17.00	1412
6	20/70	3.960 (4)	0.187	48°	3.06		0.2611	21.23	0.2659	21.62	1317
7	30/70	—		78°	2.88	3.8	0.3127	25.43	0.3124	25.40	1200
8	20/70	—		109.5°	3.15	5.1	0.3904	31.74	0.40048	32.91	1000
9	14.55/17.50	—		144.5°	2.97	5.8	0.4429	36.01	0.44449	36.17	880
10	20/70	—		174°	3.01	6.5	0.4986	40.55	0.4891	39.77	745
11	15/30	—		223°	3.08	7.4	0.5673	46.13	0.5634	45.81	537
12	30/50	—		276.7°	3.40	8.1	0.6308	51.30	0.6360	51.71	310
13	30/50	—		338°	3.09	7.8	0.6986	56.80	0.6980	56.75	120
					Mn 3.07						

No. of Obs.	Total res. on grading side	res. of wire	$\frac{R}{r}$	Log $\frac{R}{r}$	Log $\frac{R}{r}$ 0.004618	Room temp. °C.	Temp. rise	Corrected Room temp.	Log r_{19} − 10 by Lorenz	$\frac{t \text{ r.c.}}{00}$ 0.0332/0.004618 / 4.75	$\frac{I}{\text{Cond.}}$
							17.8°C		r.		
1	4260	0.03060	1.00429						$\bar{2}.455245$	1623	
2	4240 (1)	0.03044	1.0047	0.00204	1.21	1.2	.1	1.1			
3	4200 (2)	0.03102	1.0189	0.00600	3.57	3.6	.2	3.4			
4	4165 (3)	0.03144	1.0292	0.01157	6.88	6.9	.3	6.6			
5	4072 (4)	0.03240	1.0557	0.01941	11.54	11.5	.4	11.1			
6	3987 (5)	0.03277	1.0710	0.02979	17.71	17.7	.5	17.2			
7	3860 (6)	0.03376	1.103	0.04258	25.32	25.3	.6	24.7			
8	3660 (7)	0.03560	1.163	0.06558	39.0	39.0	.7	38.3			
9	3540 (8)	0.03681	1.203	0.08027	47.73	47.7	.8	46.9	0.028524		
10	3405 (9)	0.03827	1.251	0.09726	57.84	57.8	.9	56.9			
11	3197 (10)	0.04076	1.332	0.12450	74.02	74	1.0	73			
12	2970 (11)	0.04388	1.434	0.15655	93.09	93.1	1.1	92.			
13	2780 (12)	0.04688	1.532	0.18526	110.2	110.2	1.2	109			
							19.0°				

Carrying Power of Conductors.

#10

May 31st Friday) Wire tested of 116 B.W.G. double covered soft copper diamr. 0.053" = 0.2110cm
Temp. Galv. 20°C Res. 2670ω each end. covered to 0.100 = 0.254cm

No. of Obs.	Time	Object Rly.	Comut	Specimen Deflcn.	Comut	L.R. Amp.	Potnto Rly.	Amperes	Mean Potnto Rly.	Amperes	Res: on end with grading
1	15.10	-					0.07224	1.058			1700
2	$\frac{10}{20}$	0.800	0.2014	1°			0.04482	3.919	0.04287	3.960	1670
3	$\frac{20}{20}$	1.660 (1)	0.1943	8°.25	2.99		0.1051	8.5244	0.1038	8.438	1662
4	$\frac{30}{20}$	2.406 (2)	0.1922	22.3°	2.65		0.15240	12.52	0.1539	12.51	1574
5	$\frac{40}{20}$	3.240 (3)	0.1901	38.2°	2.76		0.2096	17.014	0.21024	17.11	1493
6	$\frac{50}{20}$	-		46°	3.13		0.2666	21.67	0.2669	21.70	1385
7	$\frac{50}{10}$	-		75°	3.05		0.3251	26.43	0.3157	25.67	1262
8	$\frac{50}{5}$	-		110°	2.99		0.3864	31.42	0.3875	31.51	1102
9	$\frac{50}{10}$	-		{149° / 152°}	3.06 / 3.014		{0.4590 / 0.46685}	37.32 / 37.55	0.46621	37.90	875
10	$\frac{40}{20}$	-		177°	3.00	5.8	0.4902	39.86	0.4943	40.19	752
11	$\frac{30}{20}$	-		218°	3.03	6.2	0.5490	44.63	0.5493	44.66	577
12	$\frac{20}{20}$	-		273°	3.01	6.9	0.6112	49.69	0.6132	49.86	380
13	$\frac{10}{20}$	-		343°	3.014	7.7	0.6915	56.22	0.7035	57.20	120
					Mean 3.03						

No. of Obs.	Total Res: on grading side	Resistd. Wire	$\frac{R}{r}$	$\log \frac{R}{r}$	$\log \frac{R}{r}$ / 0.0056818	Temp. air	Corrected Rise of temp.	log r −18 log 1.00338	sp. r. 0°C. 0.229	Coundi	Amp.
			0.093866								
1	4370	0.02995	1.008	0.00209		19.4°0		$\bar{2}.146613$	0.02993x		
2	4340	0.03014	1.005	0.00217	1.20 1.3	.1	1.1	.log 0.02993	0.03146 616	1097	3.46
3	4302	0.03041	1.014	0.00604	3.59 3.6	.2	3.4				6.44
4	4244	0.03082	1.027	0.01157	6.88 7.0	.3	6.6		1585		12.5
5	4162	0.03143	1.048	0.02036	12.1 12.4	.4	11.7				17.1
6	4055	0.03226	1.076	0.03181	18.92 19.7	.5	18.4				21.7
7	3932	0.03327	1.109	0.04493	26.72 27.2	.6	26.1				25.7
8	3772	0.03461	1.156	0.06296	37.44 38.5	.7	36.8				31.5
9	3555	0.03685	1.229	0.08955	53.26 54.4	.8	52.5				37.9
10	3424	0.03820	1.273	0.10483	62.34 63.4	.9	61.4				40.2
11	3247	0.04028	1.343	0.12808	76.16 77.7	1.0	75.2				44.7
12	3050	0.04290	1.430	0.15534	92.38 93.1	1.1	91.3				49.3
13	2790	0.04688	1.563	0.19396	115.34	1.2	114.0				57.2
						20.8°C.					

Meter Test. Measurement of the Rest of the new bottles.

This test commenced on the 27th May. 8 bottles were made up of the forms shewn on the opposite page. The density of solution was 1.110 and the solution was neutral. Five of these bottles were put in a warm box and three in the refrigerator. The temperature record in °F. was as follows:—

No. of Obs.	Date & Time	Period hours	Temp. °F.	Hot Box Mean	Temp. Hours	Refrigerator Temp. °F.	Refrigerator Mean	Temp. Hours	No. of Obs.	Date & Time	Period hours	Temp. °F.	Hot Box Mean	Temp. Hours	Refrigerator Temp. °F.	Refrigerator Mean	Temp. Hours
1	23.5 9.0		88	89	178	43	42		1	23.5 9.0		85	89	178	44	42	178
2	12.0	2	90	90	18.0	41	41		2	12.0	3	85	90	18.0	43	41	18.0
3	4.0	2	90	90	180	41	41	90	3	4.0	6	102	96	180	42	42	90
4	3.0	1	90	90	180	42	42	42	4	3.0	2	96	96	180	42	42	42
5	2.0	2	90	90	180	42	42	42	5	2.0	3	96	96	288	42	42	126
6	7.0	5	90	90	450	41	41	41	6	7.0	5	-	-	-	41	41	41
7	12.0	5	90	90	450	41	41	41	7	12.0	5	102	102	510	41	41	205
8	8.0	1	90	90	90	41	41	41	8	8.0	2	102	102	204	41	41	82
9	10.0	2	90	90	180	41	41	82	9	10.0	2	102	102	204	41	41	82
10	14.0	4	90	90	360	41	41	164	10	14.0	4	96	96	384	41	41	164
11	19.0	5	90	90	450	42	42	210	11	19.0	5	96	96	480	42	42	210
12	22.0	3	90	90	270	42	42	126	12	22.0	3	96	96	288	42	42	126
13	23.5	1.5	90	90	135	42	42	63	13	23.5	1.5	96	96	144	42	42	63
14	24.5	1	90	90	90	42	42	42	14	24.5	1	96	96	96	42	42	42
15	1.5	1	90	90	90	41	41	41	15	1.5	1	96	96	96	41	41	41
16	2.5	1	90	90	90	41	41	41	16	2.5	1	96	96	96	41	41	41
17	8.0	5.5	90	90	495	41	41	225	17	8.0	5.5	96	96	528	41	41	225
18	12.0	4	90	90	360	42	42	168	18	12.0	4	96	96	384	42	42	168
19	16.0	4	90	90	360	42	42	168	19	16.0	4	96	96	384	42	42	168
20	19.0	3	90	90	270	42	42	126	20	19.0	3	96	96	288	42	42	126
21	20.0	1	90	90	90	42	42	42	21	20.0	1	96	96	96	42	42	42
22	21.0	1	90	90	90	42	42	42	22	21.0	1	96	96	96	42	42	42
23	22.5	1.5	90	90	135	42	42	63	23	22.5	1.5	96	96	144	42	42	63
24	23.5	1	90	90	90	42	42	42	24	23.5	1	96	96	96	42	42	42
25	1.5	2	90	90	180	42	42	84	25	1.5	2	96	96	192	42	42	84
26	3.5	2	90	90	180	42	42	84	26	3.5	2	96	96	192	42	42	84
27	5.5	2	90	90	180	42	42	84	27	5.5	2	96	96	192	42	42	84
28	7.5	2	90	90	180	42	42	84	28	7.5	2	96	96	192	42	42	84
29	9.5	2	90	90	180	42	42	84	29	9.5	2	96	96	192	42	42	84
30	11.5	2	90	90	180	42	42	84	30	11.5	2	96	96	192	42	42	84
31	13.5	2	90	90	180	42	42	84	31	13.5	2	96	96	192	42	42	84
32	15.5	2	90	90	180	42	42	84	32	15.5	2	96	96	192	42	42	84
33	17.5	2	90	90	180	42	42	84	33	17.5	2	96	96	192	42	42	84
34	19.5	2	90	90	180	42	42	84	34	19.5	2	96	96	192	42	42	84
35	21.5	2	90	90	180	42	42	84	35	21.5	2	96	96	192	42	42	84
36	23.5	2	90	90	180	42	42	84	36	23.5	2	96	96	192	42	42	84
37	1.5	2	90	90	180	42	42	84	37	1.5	2	96	96	192	42	42	84
38	3.5	2	90	90	180	42	42	84	38	3.5	2	96	96	192	42	42	84
39	5.5	2	90	90	180	42	42	84	39	5.5	2	96	96	192	42	42	84
40	7.5	2	90	90	180	42	42	84	40	7.5	2	96	96	192	42	42	84
41	9.5	2	90	90	180	42	42	84	41	9.5	2	96	96	192	42	42	84
42	11.5	2	90	90	180	42	42	84	42	11.5	2	96	96	192	42	42	84
43	13.5	2	90	90	180	42	42	84	43	13.5	2	96	96	192	42	42	84
44	15.5	2	90	90	180	42	42	84	44	15.5	2	96	96	192	42	42	84
45	17.5	2	90	90	180	42	42	84	45	17.5	2	96	96	192	42	42	84
46	19.5	2	90	90	180	42	42	84	46	19.5	2	96	96	192	42	42	84
47	21.5	2	90	90	180	42	42	84	47	21.5	2	96	96	192	42	42	84
48	23.5	2	90	90	180	42	42	84	48	23.5	2	96	96	192	42	42	84
49	24.5	1	90	90	90	42	42	42	49	24.5	1	96	96	96	42	42	42
50	1.0	2	90	90	180	42	42	84	50	1.0	2	96	96	192	42	42	84
51	3.0	2	90	90	180	42	42	84	51	3.0	2	96	96	192	42	42	84
52	5.0	2	90	90	180	42	42	84	52	5.0	2	96	96	192	42	42	84
53	7.0	2	90	90	180	42	42	84	53	7.0	2	96	96	192	42	42	84
54	9.0	2	90	90	180	42	42	84	54	9.0	2	96	96	192	42	42	84
55	11.0	2	90	90	180	42	42	84	55	11.0	2	96	96	192	42	42	84
56	13.0	2	90	90	180	42	42	84	56	13.0	2	96	96	192	42	42	84
57	15.0	2	90	90	180	42	42	84	57	15.0	2	96	96	192	42	42	84
58	17.0	2	90	90	180	42	42	84	58	17.0	2	96	96	192	42	42	84
	Consult Jon	113.5			324 81.5					Consult Jon	113.5						
										Mean temp.							
														1372	46		
														3567	44		
														4969	45		
														44.57°	44		
														6.5°			
																	3587

The current strength was 5×10^{-3} amperes so that the full deposit should be $5 \times 10^{-3} \times 1.135 \times 10^{-3} \times 1.2244 = 0.0695$ grammes. The actual amount was observed to be 730 or 5% greater.

Three of the bottles in the hot box and all three in the refrigerator were shunted. The current strength was found to have been excessive and the plates in the refrigerator were found to have smutted.

Measurement of Metre-Bottle Resistance.

No. of Plate	Weight 22.5.89	Weight 31.5.89	Gain	Loss	Gain of couple	Mean of gain + loss	Accepted total defl.	Res. of shunt	Total to temp.	W-w
1	54.455	55.191	0.736							
				0.720	0.006	0.723			∞	
2	55.566	54.836					0.730			
3	55.168	55.898	0.730						∞	
				0.725	0.005	0.728				
4	54.090	55.315								
5	52.660	53.092	0.432							
				0.425	0.007	0.429			2.11	0.201
6	54.645	54.220								
7	49.502	50.020	0.518							
				0.501	0.017	0.510			2.12	0.220
	54.921	54.420								
9	56.003	56.445	0.442							
				0.436	0.006	0.439			2.14	0.291
10	55.413	54.977								
11	35.178	34.927	0.257							
				0.251	0.006	0.254			4.19	0.476
12	54.962	55.219								
13	54.664	54.845	0.201							
				0.183	0.018	0.197			4.17	0.533
14	53.788	53.600								
15	53.000	53.351	0.351							
				0.349	0.002	0.350			4.20	0.380
16	54.424	54.075								

No. of plate	$\frac{W-w}{w}$	Res. of bottle	Mean	Mean Temp.
1				
2				
3				
4				
5	0.702	1.481		
6				
7	0.431	0.914	1.272 ω	31.4°C
8				
9	0.663	1.420		
10				
11	0.187	7.72		
12				
13	0.271	11.30	7.87 ω	6.5°C.
14				
15	0.109	4.58		
16				

Rough Calculation of the variation of the Earth's Potential ($\frac{dV}{dt}$) in time, on the supposition that the sun is an electrified body.

The e.m.f. required to break across air is about 100,000 volts for 3 cms. In a mile there are about 160,000 cms so that the culminating p.d. for a lightning flash one mile long is about 5000 million volts. Assuming that the sun possesses a potential of 1.0×10^{12} or a billion volts or 3.33×10^{9} abs. e.m.u. its capacity being 6.832×10^{11}, its charge would be 2.273×10^{13}. The apogee distance of the earth being given as 9.297×10^{7} miles $\times 1.6093 \times 10^{5} = 1.4961 \times 10^{13}$ and its perigee distance being 8.990×10^{7} $\times 1.6093 \times 10^{5} = 1.4462 \times 10^{13}$, the potential of the earth is respectively $\frac{2.273 \times 10^{13}}{1.4961 \times 10^{13}} = 1.831 \times 10^{6}$ and $\frac{2.273}{1.4462} \times 10^{6} = 1.576 \times 10^{6}$ ~~volts~~ abs e.m.u. and the difference 2.55×10^{5} units is spread over half a year or 1.578×10^{7} sec corresponding to a mean time rate of variation of potential equal to 1.616×10^{-2} or about 14.84 volts nearly 5 volts per sec.

Tests of a certain sample of Insulating Material supplied by Mr. Insull.

Four specimens of brown composition were received on the 3rd June. These had been moulded in a sweet-press.
One of these was left from 17 o'clock to 10 next morning on the hot plate of the day engine. Another was left to soak for the same period in water. The specimen was in the form of a dish was 4·2 (1⅝") diam by 0·9 (⅜") thick. Its res: between two plates of zinc after being wiped superficially dry was 10,000 ω under 9½ oz
(in the latter case the sp res would be 43,800 ω under pressure of 28 grammes 2500 ω - 27½ -
Weight of sample in damp state 27 grammes
hot and dried 24·14 "
The volume of this sample being 11·114 c.c.
Its sp. g: is 24·14/11·114 or 2·19 and its gain by soaking is 23·4 % by volume, in water or 10·5% by weight.
The material appeared to be practically uninflammable as it would not keep aflame after ignition by a bunsen burner even if in small chips.
After exposing for 2½ hours to water vapor rising from an evaporating basin, its weight rose to 24·6 gms. a gain of not quite 1% and the insulation fell slightly.
Acids do not seem to affect it greatly.

Trial of Paris Meters.

Six two wire meters intended for official tests at Paris were received from Bergmann & Co on Wednesday 5th June. They were set up for trial the same evening. The bottles were of the new pattern #4 size. The zinc was cast 5%. filed at the lower corners. The bottles were closed with corks. There were two bottles in each meter. The meters are designed for a deposit of one milligramme per ampere-hour and the resistances of copper and german silver wire were prepared on the values given at page 110.

The plates were all amalgamated hot and weighed after drying. It was observed in one instance that a hole having been overlooked in wiping off excessive amalgam the removal of a small quantity on the thread of the screw together with what was then brushed out amounted to nearly 30 mgms. The solution was 1·054 quite neutral. The six meters were joined in series with the two standards and the current of about 10 amperes put through them all at 22·30.

Carrying Power of Conductors.

Thursday June 6th

#11 Wire no. 12 BWG Diam. 0·109" covered to 0·176". Black-house wire.
0·2768cm 0·447cm Over [illegible]

Res. of galv 5360 = 2680 each side @ 68°F 19°C.

No. of Obs.	Obsch Rdg.	Constant	Sumner Dynm. Rdg.	Constant	Long range Galv rdg	Amplifier	Potentiometer Rdg.	Amplifier	Mercury Resistor rdg.	Amplifier	Time
1	0·800		5·5°		–		0·04495		0·04486	3·967	13 30/60
2	0·800								0·04486	3·967	13 35/60
3	1·000 (1)	0·193	12°	2·423	–		0·1020	8·408	0·1020	8·408	13 50/60
4	2·370 (2)	0·186	21°	2·767	–		0·1556	12·70	0·1557	12·73	13 55/60
5	3·150 (3)	0·182	39°	2·763	–		0·2116	17·27	0·2120	17·467	14 20/60
6	–		56·5°	2·958	2·00	20·25	0·2724	22·24	0·27424	22·40	14 35/60
7	–		76°	3·270	3·00	22·65	0·3267	26·67	0·3290	26·85	14 50/60
8	–		116°	3·040	4·05	30·[illegible]	0·4015	32·77	0·4017	32·79	14 55/60
9	–		131·7	2·969	4·5	33·[illegible]	0·4192	34·22	0·4222	34·46	15 25/60
10	–		155·5	3·023	5·0	35·42	0·4618	37·70	0·4615	37·67	15 35/60
11	–		194°	3·058	5·75	40	0·5217	42·59	0·5257	42·92	15 50/60
12	–		251°	3·062	6·16	44	0·5953	48·60	0·5926	48·38	16 20/60
13	–		287°	3·078	6·95	50	0·6244	51·14	0·6266	50·99	16 35/60
14	–		336·5°	3·036	7·5	55	0·6824	55·71	0·6823	55·70	16 50/60
15	–			6495	7·9	57	0·7222	58·96	0·7365	60·12	17 20/60
16			Mean	3·063	8·4	61	0·7872	64·26	0·7769	63·43	17 35/60
17					9·0	66·44	0·8440	68·90	0·8453	69·0	17 50/60
18					9·4	71	0·9060	73·96	0·9038	73·78	18 20/60

No. of Obs.	Res. in set with grating	Total res. grating side	Res. of wire	$\frac{R}{r}$	$\log \frac{R}{r}$	$\log \frac{R}{r}$ / 0·076018	Temp. air	Rise of temp.	$\log r$ − 2 log Lorenz	of resistance	Conductivity
1	4550	7230	0·07817				22°C		$\bar{2}$·25565	0·07902	
2	4540	7220 (1)	0·07819	1·001	0·000434	–			= 0·07816	÷ 0·07601	89·6%
3	4510	7190 (2)	0·07826	1·005	0·002166	1·29	0·1	0·31 1·2		÷ 615	
4	4450	7130 (3)	0·07842	1·014	0·00600	3·59		1·07 3·5		= 1761	
5	4425	7105 (4)	0·07849	1·018	0·00775	4·61	0·2	0·7 4·4			
6	4350	7030 (5)	0·07868	1·028	0·01199	7·13		2·2 6·9			
7	4265	6945 (6)	0·07891	1·041	0·01745	10·38	0·3	3·3 10·1			
8	4135	6815 (7)	0·07927	1·061	0·02572	15·29		4·8 15·0			
9	4000	6730 (8)	0·07951	1·074	0·03100	18·43	0·4	5·8 18·0			
10	3960	6640 (9)	0·07978	1·089	0·03703	22·02		7·1 21·6			
11	3812	6492 (10)	0·08023	1·113	0·05209	31·57	0·5	8·2 31·1			
12	3645	6325 (11)	0·08076	1·143	0·05805	34·52		10·0 34·6			
13	3500	6180 (12)	0·08125	1·170	0·06819	40·55	0·6	11·0 40·1			
14	3337	5017 (13)	0·08183	1·202	0·07990	47·51		12·9 46·9			
15	3176	5850 (14)	0·08245	1·235	0·09147	54·51	0·7	14·1 53·8			
16	2990	5670 (15)	0·08316	1·275	0·10551	62·73		15·6 62·			
17	2795	5475 (16)	0·08398	1·320	0·12057	71·70	0·8	17·2 70·9			
18	2600	5280 (17)	0·08487	1·369	0·13640	81·10	2300	18·8 80·2			

Carrying Capacity of Conductors.

June 7th Friday

Wire tested Black braided housewire covered Diam conductor + 11 B&S 14.160 cir. mm. 0.119" 0.302 mm. 0.165" 0.419

Res. of 9 2670 ω each side

No. of Obs.	Time	Obsd. Defl.	Const:	Sumaire Dynamo Rdg.	Constant	Clothworkers L.R. Galv.	Amperes	Potentiometer	816 Amperes	Mean Potentiometer Rdg.	1552 Amperes
1	15.30	1.005	0.192	4.5	2.45			0.0635	5.182	0.0635	5.182
2	15.$\frac{30}{35}$	+ "	0.220							0.0632	5.156
3	15.$\frac{40}{50}$	2.32	0.220	16.	2.64			0.1297	10.57	0.1308	10.67
4	15.$\frac{55}{16.00}$	3.02	0.191	31.7	2.80			0.1934	15.78	0.1923	15.69
5	16.$\frac{05}{10}$	—		44.5	2.99	1.77	19	0.2447	19.97	0.2454	20.02
6	16.$\frac{15}{20}$	.		113	3.06	4.0	29.63	0.3976	32.44	0.3977	32.46
7	16.$\frac{25}{30}$	.		217.5	3.107	5.95	49.2	0.5613	45.80	0.5607	45.76
8	16.$\frac{35}{40}$	.		311	3.08	7	49.22	0.6662	54.36	0.6710	54.76
9	16.$\frac{45}{50}$	.		—		8.2	58	0.7996	65.25	0.7958	64.93
10	16.$\frac{55}{17.00}$					9.4	71	0.9316	76.02	0.9315	76.02
11	17.$\frac{05}{10}$					10.2	79	1.0548	88.52	1.0896	88.94
12	17.$\frac{15}{20}$					11.2	90	1.2564	102.5	1.2574	102.3

No. of Obs.	Res. in cot. with glazing	Total Res. in glazing coils	Res. of wire	$\frac{R}{r}$	$\log \frac{R}{r}$	$\log \frac{S}{0.001618}$	Temp. air	°C Rise in wire	$\log r - 2.3 \log 1.00386$	sp. res. 0°C	conduct.
1	1670	4340	0.01537	1.			22°C.		5.17811 0.03700 5.14111 0.03324	0.01324 ×0.7163 ÷ 615	98.25%
2	1670	4340	0.01537	1.							
3	1650	4320	0.01574	1.0247	0.00926	1.21	0.1	0.7	1.		
4	1622	4292	0.01525	1.012	0.00518	3.08	0.2	2.9	2.9	1612	
5	1595	4265	0.01534	1.018	0.00775	4.61	0.3	4.3	4.3		
6	1485	4155	0.01575	1.045	0.01912	11.37	0.4	11.	11.		
7	1322	3992	0.01639	1.088	0.03663	21.78	0.5	21.3	21.3		
8	1152	3822	0.01712	1.136	0.05538	32.93	0.6	32.3	32.3		
9	980	3650	0.01793	1.190	0.07555	44.92	0.7	44.2	44.2		
10	715	3385	0.0193	1.281	0.10755	63.96	0.8	63.2	63.2		
11	492	3162	0.0207	1.373	0.13767	81.86	0.9	81.	81.		
12	220	2890	0.02264	1.502	0.17667	105.1	23°C	104.1	104.1		

Results of first test of Edison Meters for Paris Competition.

The meters were at work for 37 hours in all. The test was stopped at 9.0 8th June Saturday, plates dried and weighed with following results:—

No. of Plate	Weight 5. VI. 89	Sum: Pair Weight	Weight 8. VI. 89	Sum Pair Weight	Gain of Couple	Plate Loss	Plate Gain	Mean of Loss + Gain	Standard corrections	General Mean Embracing # 3	Ratio.
1	116.3860	234.4697	116.8316	234.4897	+0.0320	0.4326	0.4456	0.4391			
2	118.0915		117.6581								
3	117.7612	235.6957	117.9134	237.6938	−0.0019	0.1541	0.1522	0.1532			
4	117.9345		117.7804								
5	116.4787	240.3384	117.3644	240.3381	+0.0002	0.4485	0.4507	0.4496			1.007 07%
6	123.8222		122.9737								
7	115.5380	233.6391	116.2919	233.6372	−0.0019	0.4339	0.4358	0.4348			
8	117.7012		117.3453								
9	115.5362	232.0316	116.0054	232.0749	+0.0403	0.4289	0.4692	0.4491			
10	116.4954		116.0695								
11	116.9226	234.7191	117.3893	234.7438	+0.0247	0.4350	0.4597	0.4474		4474.2	0.994 −06%
12	117.7965		117.3615								0.994
13	116.6016	232.5614	117.0500	232.5679	+0.0065	0.4419	0.4484	0.4451			
14	115.9598		115.5179								
15	116.6105	234.1415	117.0703	234.1617	+0.0202	0.4396	0.4598	0.4497			
16	117.5310		117.0914								
17	117.7770	237.0446	118.2345	237.0657	+0.0213	0.4362	0.4675	0.4467			
18	119.2676		118.8312								
19	119.7560	235.6877	118.1910	235.6970	+0.0093	0.4287	0.4380	0.4334			0.970 −3%
20	115.9317		115.5030								
21	118.2260	237.4142	118.6761	237.4276	+0.0134	0.4387	0.4521	0.4454			
22	119.1902		118.7515								
23	115.4053	230.8021	115.8610	230.8211	+0.0190	0.4367	0.4557	0.4462			
24	115.3968		114.9601							4510	
25	81.9275	168.5938	81.9804	168.6055	+0.0117	0.5471	0.5588	0.5530	0.5520		
26	86.6663		87.2251								
Sum	168.5938		168.6055							0.5468	
27	82.9398	164.4119	85.4734	164.3855	−0.0234	0.5560		0.5443	0.5445	= 1116.8	
28	79.4721		78.9161							aup. Inc.	
Pair	164.4135		164.3874				0.5326				

The solution was quite neutral

The mean couple gain is 14 mgms or 7 per plate

No. 3/4 bottle was found short circuited by a screw that had been missing and which rusted on the copper strips.

No. 19 plate was the only one that smutted. No reason could be assigned.

The mean error is 0.6% deficit

max: deficit 3%

" excess 0.7%.

These meters were set on a second test 10th June the solution being very slightly acid. (1 drop).

By this formula when $x = 12$ $X = 15.15$ $R = 7.03$ $r = 4.98$ $bh = 6.32$

$$C = \frac{6.32\,H}{6.283}\left\{\frac{1}{15.15\,\log_e\frac{7.03+16.7}{4.98+18.95} - 12\,\log_e\frac{7.03+19}{4.98+13}}\right.$$

$\frac{23.73}{20.93}$	$\frac{20.93}{17.98}$
1.1344	1.1644
$M \times 0.054461$	$M \times 0.06575$
$\bar{3}.73727$	$\bar{3}.81921$
$\frac{43439}{\bar{1}.17156}$	$\frac{.14324}{\bar{1}.35596}$
.14824	0.1793
2.2248 —	2.152

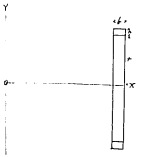
0.096

$$= \frac{6.32 \times 0.19 \times 10 \times 10.42}{6.283} = \frac{6.32 \times 1.9 \times 1.0042 \times 10^1}{6.283} = 19.92$$

By the shorter and less accurate method $= 20.28$

Error of latter in excess 1.8% = maximum error

Investigation of the Degree of Error in the use of the Long Range Ammeter at short ranges.



Let R and r be the ext: and int: radii of the ring and $R = r + b$

- b = the breadth of the ring.
- the axis of the ring be the x axis.
- at O let a magnet be placed of negligible length and unit pole strength.

Then if the current circulating in the coil be C and the area of the ring $= bh$ then the current per unit area $= \frac{C}{bh} = c$

The force exerted by any elementary rectangular ring of coordinates in section x and y will be horizontally at O

$$df = \frac{2\pi c\, y^2}{(x^2+y^2)^{\frac{3}{2}}} \quad \text{so that the whole force exerted is}$$

$$f = 2\pi c \int_r^{r+b}\int_x^{x+b} \frac{y^2\,dx\,dy}{(x^2+y^2)^{\frac{3}{2}}}$$

$$dy\,y^2\int_x^{x+b}\frac{dx}{(x^2+y^2)^{\frac{3}{2}}} = y^2\,dy\left[\frac{x}{y^2\sqrt{x^2+y^2}}\right]_x^{x+b} = dy\left\{\frac{x+b}{\sqrt{(x+b)^2+y^2}} - \frac{x}{\sqrt{x^2+y^2}}\right\}$$

$$\text{let } \left.\begin{array}{l} x+b = f \\ x \quad = g \end{array}\right\} \therefore\ f = 2\pi c\int_r^{r+b}\left\{\frac{f}{\sqrt{f^2+y^2}} - \frac{g}{\sqrt{g^2+y^2}}\right\}dy$$

$$= 2\pi c f\int_r^{r+b}\frac{dy}{\sqrt{f^2+y^2}} - 2\pi c g\int_r^{r+b}\frac{dy}{\sqrt{g^2+y^2}}$$

$$= 2\pi c f\left[\log_e\left(y+\sqrt{f^2+y^2}\right)\right]_r^{r+b} - 2\pi c g\left[\log_e\left(y+\sqrt{g^2+y^2}\right)\right]_r^{r+b}$$

$$= 2\pi c\left\{f\log\frac{R+\sqrt{f^2+R^2}}{r+\sqrt{f^2+r^2}} - g\log_e\frac{R+\sqrt{g^2+R^2}}{r+\sqrt{g^2+r^2}}\right\}$$

$$= 2\pi c\left\{X\log_e\frac{R+\sqrt{X^2+R^2}}{r+\sqrt{X^2+r^2}} - x\log_e\frac{R+\sqrt{x^2+R^2}}{r+\sqrt{x^2+r^2}}\right\}$$

balancing against H

$$C = \frac{bh\,H}{2\pi}\left\{\frac{1}{X\log_e\frac{R+\sqrt{X^2+R^2}}{r+\sqrt{X^2+r^2}} - x\log_e\frac{R+\sqrt{x^2+R^2}}{r+\sqrt{x^2+r^2}}}\right\}$$

For an ordinary tangent galvo $x = -X$

$$\text{whence } C = \frac{bh\,H}{2\pi}\left\{\frac{1}{+2X\log_e\frac{R+\sqrt{X^2+R^2}}{r+\sqrt{X^2+r^2}}}\right.$$

$$= \frac{2\beta h\,H}{4\pi X}\,\frac{1}{\log_e\frac{R+\sqrt{X^2+R^2}}{r+\sqrt{X^2+r^2}}} \quad \text{let } b = 2\beta$$

$$= \frac{2\beta h\,H}{4\pi\beta}\,\frac{1}{\log_e\frac{R+\sqrt{\beta^2+R^2}}{r+\sqrt{\beta^2+r^2}}}$$

$$= \frac{hH}{2\pi\beta}\times\frac{1}{\frac{1}{h}\log_e\frac{R+\sqrt{\beta^2+R^2}}{r+\sqrt{\beta^2+r^2}}}$$

If there are N turns in the space $2\beta h$ we have $Nc = C$ $\therefore C = \frac{C}{N}$

$$\text{current in each turn} = \frac{H\tan\theta}{2\pi N\,\frac{1}{h}\log_e\frac{R+\sqrt{\beta^2+R^2}}{r+\sqrt{\beta^2+r^2}}}$$

No. of obs.	sp. res. obsd.	sp. res. calculated z	$z-M$ v	v^2	Σv^2	$\sqrt{\frac{\Sigma v^2}{n-3}}$	$\cdot 6745\sqrt{\frac{M}{L}}$	r				
1	31·10	30·92	− 0·18	0. 0324								
2	26·36	26·35	− 0·01	·0001								
3	23·88	24·11	+ 0·23	·0529		$\sqrt{0\cdot0302}$						
4	22·76	22·88	+ 0·12	·0144	0·1209	= 0·1774	0·117	± 0·12.				
5	20·45	20·34	− 0·11	·0121								
6	18·62	18·53	− 0·09	·0081								
7	15·86	15·89	+ 0·03	·0009								

(20)

Comparison of Von Beta's Determination of the sp. res. of $In\,SO_4$ solution with those made here.

From series #3 of his results, subsequently mentioned to have been a good one, and with the sp. res. of pure Hg: as 0·9534 also the legal ohm as 0·9887 BA u we have from page 9 Vol CXIII Pogg Ann. Phys. Observations equivalent as far as 53°C

$$
\begin{aligned}
a + 15\cdot7\,b + 246\cdot5\,c &= 31\cdot10 & \qquad 15\cdot7a + 246\cdot5b + 3869\cdot9c &= 488\cdot27\\
a + 23\cdot5\,b + 552\cdot3\,c &= 26\cdot36 & \qquad 23\cdot5b + 552\cdot3b + 12977\cdot9c &= 619\cdot46\\
a + 27\cdot8\,b + 772\cdot8\,c &= 23\cdot88 & \qquad 27\cdot8a + 772\cdot8b + 21485\cdot0c &= 663\cdot86\\
a + 30\cdot4\,b + 924\cdot2\,c &= 22\cdot76 & \qquad 30\cdot4a + 924\cdot2b + 28094\cdot5c &= 691\cdot90\\
a + 36\cdot6\,b + 1339\cdot6\,c &= 20\cdot45 & \qquad 36\cdot6a + 1339\cdot6b + 49027\cdot9c &= 748\cdot47\\
a + 41\cdot9\,b + 1755\cdot6\,c &= 18\cdot62 & \qquad 41\cdot9a + 1755\cdot6b + 73560\cdot1c &= 780\cdot17\\
a + 53\cdot3\,b + 2840\cdot9\,c &= 15\cdot86 & \qquad 53\cdot3a + 2840\cdot9b + 151419\cdot4c &= 845\cdot33.\\
\hline
7a + 229\cdot2\,b + 8431\cdot9\,c &= 159\cdot03 & \qquad 229\cdot2a + 8431\cdot9b + 340434\cdot7c &= 4837\cdot46
\end{aligned}
$$

$$
\begin{aligned}
246\cdot5a + 3869\cdot9b + 60800c &= 7666\cdot2\\
552\cdot3a + 12977\cdot9b + 305000c &= 14558\cdot6\\
772\cdot8a + 21485\cdot0b + 597000c &= 18454\cdot6\\
924\cdot2a + 28094\cdot5b + 850400c &= 21832\cdot8\\
1339\cdot6a + 49027\cdot9b + 1795600c &= 27394\cdot5\\
1755\cdot6a + 73560\cdot1b + 3080000c &= 32869\cdot3\\
2840\cdot9a + 151419\cdot4b + 8664000c &= 45056\cdot7\\
\hline
8431\cdot9a + 340434\cdot7b + 14758400c &= 166855.
\end{aligned}
$$

So that the normal equations

$$
\begin{aligned}
7a + 229\cdot2b + 8432c &= 159\cdot0 \qquad (1)\\
229\cdot2a + 8431\cdot9b + 340435c &= 4837\cdot5 \qquad (2)\\
8431\cdot9a + 340435b + 14758400c &= 166855 \qquad (3)
\end{aligned}
$$

From (1) $\quad a = 159/7 - 229\cdot2b/7 - 8432c/7 = 22\cdot71 - 32\cdot75b - 1204\cdot6c$

" (2) $\quad 5205 - 7506b - 276100c$
$\quad + 8432\cdot b + 340440c = 4838 \Big\} \; 926b + 4435c = -367 \quad (a)$

" (3) $\quad 191490 - 2761500b - 10159000c$
$\quad + 340435b + 14758400c = 166855 \Big\} \; 64285b + 4599400c = -24635$

" (4) $\quad b = \dfrac{-367}{926} - \dfrac{4435c}{926} = -0\cdot3964 - 4\cdot9c$

" (5) $\quad -254824 - 4467000b +$
$\quad + 4599400c = -24635 \Big\} \; 132400c = 849 \quad (b)$

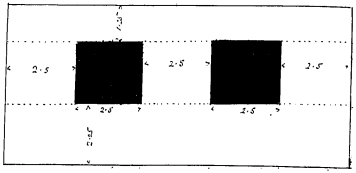
" (6) $\quad c = 0\cdot006411$

" $\quad b = -0\cdot44456 - 0\cdot3964 = -0\cdot84420$

" $\quad a = 22\cdot71 + 27\cdot57 - 7\cdot72 = 42\cdot56$

Check. $\quad 8432 \times 42\cdot56 + 340435 \times -0\cdot84420 + 14758400 \times 0\cdot006411 = 166855 = 0$
$\quad 358850 - 286600 + 94850 - 166855 = +25$

$$
\begin{aligned}
42\cdot56 + 15\cdot7 \times 0\cdot8442 + 246\cdot5 \times 0\cdot006411 &= 42\cdot56 \quad v \\
42\cdot56 + 23\cdot5 + 552\cdot3 &\quad -13\cdot22 + 15\cdot58 = 30\cdot92 - 0\cdot19\\
42\cdot56 + 27\cdot8 + 772\cdot8 &\quad -19\cdot75 + 3\cdot54 = 26\cdot35 - 0\cdot01\\
42\cdot56 + 30\cdot4 + 924\cdot2 &\quad -23\cdot40 + 4\cdot95 = 24\cdot11 + 0\cdot23\\
42\cdot56 + 36\cdot6 + 1339\cdot6 &\quad -25\cdot60 + 5\cdot92 = 22\cdot88 + 0\cdot12\\
42\cdot56 + 41\cdot9 + 1755\cdot6 &\quad -30\cdot91 + 8\cdot59 = 20\cdot34 - 0\cdot11\\
42\cdot56 + 53\cdot3 + 2840\cdot9 &\quad -35\cdot28 + 11\cdot25 = 18\cdot53 - 0\cdot09\\
&\quad -44\cdot88 + 18\cdot21 = 15\cdot89 - 0\cdot03
\end{aligned}
$$



Carrying Capacity of Conductors.

June 12th Wednesday.

Abandoned the wooden casing hitherto used in favor of a larger one whose dimensions are as follows –

Length 60 cms Breadth 12.5 height 5.75.

Placed in it both the specimens last tested and a black horse-wire diam: 0.163" = 0.4114cm covered to 0.228" = 0.579 # 8 B.W.G.

Res: of gales 53 gos = 27.00 T.B. 24°C. T.g. 23.3°C.

No of Obs.	Time	Shunt	Coarse	L. R. Am	Fine	Potentio	Amperes	Mean Potentio Reg.	Amperes	Res: in est with #11 wire	Total Res gauging side	Res: of #11
1	13.35	1.05		–		0.06444	5.265	0.0643	5.247	1690	12.90	0.01507
2	.35	1.96				0.1227	10.01	0.1222	9.97	1670	12.70	0.01574
3	.40	2.90				0.1900	15.51	0.1912	15.60	1660	12.60	0.01521
4	.40									1610	12.10	0.01385
5	.45			1.95		0.2682	21.28	0.2890	21.13	1580	12.80	0.01526
6	.45			2.90		0.3089	25.21	0.3102	25.32	1525	12.25	0.01666
7	.45			4.25		0.3778	30.83	0.3774	30.80	1470	12.70	0.01556
8	.45			5.7		0.5020	41.04	0.5033	41.07	1322	10.27	0.01622
9	.45			7.1		0.6206	50.65	0.6172	50.37	1187	28.87	0.01701
10	.50			8.45		0.7576	61.82	0.7585	61.89	965	36.65	0.01800
11	.50			9.86		0.9138	74.56	0.9058	73.92	722	31.22	0.01933
12	.50			10.8		1.0174	85.45	1.0182	83.08	532	32.32	0.02047
13	.50			11.2		1.1204	91.42	1.1210	91.47	322	30.22	0.02159
14	.50			12.25		1.2516	102.1	1.2440	103.2	96	27.96	0.02366
15	.50			13.22		1.4064	114.2	1.4226	116.9	–	–	
16	.50			13.6		1.500	122.4	1.4562	122.1	–	–	
				14.14		1.6158	131.8	1.6210	132.3	–	–	
				20.96								

No of Obs.	R/F	log R/F	Res: in est with Platinum #8 B.W.G.	Total Res gauging side	Res: of No 8	R/F	log R/F corrected	Temp: air	°C. rise for #11	°C. rise for #8 wire	Rise with for bank resistance	
1	1.005	0.02217	5870	8270	0.007998	1.000	0.	22.8	1.29	0.5.11	1.2	0.4
2	1.009	0.00359	5550	8220	0.008018	1.002	0.00446	·1	2.31	1.55	2.1	1.44
3	1.019	0.00917	5525	8225	0.008043	1.006	0.00260	·2	4.86	2.57	4.6	2.3
4	1.026	0.01115	5485	8185	0.008091	1.010	0.00422	·3	6.63	3.85	6.2	3.5
5	1.039	0.01662	5450	8150	0.008115	1.015	0.00647	·4	9.88	5.88	9.4	5.4
6	1.052	0.02202	5385	8085	0.008181	1.023	0.00988	·5	13.10	9.63	12.5	9.0
7	1.070	0.02943	5270	7970	0.008302	1.038	0.01620	·6	22.26	11.44	21.6	12.7
8	1.120	0.05308	5120	7820	0.008458	1.0878	0.02628	·7	31.57	19.87	30.8	19.1
9	1.198	0.07846	4965	7660	0.008686	1.080	0.03342	·8	46.66	32.47	45.8	31.6
10	1.283	0.10823	4690	7290	0.009074	1.134	0.05461	·9	64.35	36.1	63.4	35.1
11	1.359	0.13322	4490	7190	0.009200	1.150	0.06070	1·0	79.22	46.0	78.1	44.9
12	1.453	0.16227	4217	6917	0.009562	1.195	0.07737	1·1	96.8	55.34	95.3	54.7
13	1.570	0.19590	3975	6675	0.009912	1.239	0.09307	1·2	116.5	71.1	115.3	69.9
14			3580	6280	0.01053	1.317	0.11959	1·3		81.3		80.1
15			3335	6035	0.01096	1.370	0.13672	1·4		92.36		91.2
16			3080	5780	0.01144	1.430	0.15534	2·4				

v	
−0.0065	
−0.0047	
−0.0002	
−0.0049	
+0.0035	
+0.0003	
+0.0047	
−0.0016	
+0.0007	
−0.0006	
+0.0013	
Mean	362/11 = −0.0033

Test of Paris Meters (2nd Trial)

Results of 2nd trial of meters with very slightly acid solution. Otherwise the same conditions. Test commenced 16.—10. VI and lasted just 48 hours.

No. of plate	Weight 10. VI. 89.	Couple weight	Weight 13. VI. 89	Couple weight	Couple Gain	Plate Loss	Plate Gain	Mean Loss or Gain	Standard correction	General Mean	
1	117.2968	233.9714	117.7212	233.9622	−0.0032	*					
2	116.6746		116.2470			0.4276	0.4224	0.4260			
3	115.2759	224.8257	115.6902	224.2203	−0.0054						
4	109.5528		109.1299			0.4229	0.4175	0.4202			
5	116.4040	231.4789	115.9948	231.4758	−0.0031						
6	115.0749		115.6910			0.4192	0.4161	0.4177			
7	116.8020	232.7080	117.2254	232.7100	+0.0020						
8	115.9060		115.4846			0.4214	0.4234	0.4224			
9	122.1896	227.4888	122.6011	237.4135	−0.0053						
10	115.2992		114.8124			0.4168	0.4115	0.4142			
11	117.3022	236.1677	117.7199	236.1661	−0.0016						
12	118.8632		118.4462			0.4173	0.4157	0.4165			
13	117.4866	234.5575	117.8961	234.5522	−0.0053						
14	117.0709		116.6561			0.4148	0.4095	0.4122		417.5	0.9782
15	114.9771	233.6126	115.3275	233.6073	−0.0047						
16	118.6349		118.2798			0.4151	0.4104	0.4128			
17	116.0605	232.8696	116.4767	232.8634	−0.0062						
18	116.8091		116.3867			0.4224	0.4162	0.4193			
19	116.5989	232.8839	116.9201	232.8768	−0.0071						
20	116.3750		115.9567			0.4183	0.4112	0.4148			
21	115.1630	232.9014	115.5799	231.9990	−0.0024						
22	116.8384		116.4191			0.4193	0.4169	0.4181			
23	117.9267	233.8267	118.3100	233.8209	−0.0058						
24	115.9000		115.4809			0.4191	0.4133	0.4162			
25	85.8542	163.5442	86.2718	163.5335	−0.0107						
26	77.6900		77.1617			0.5283	0.5176	0.5230	.5241	428.2	
	163.5442									426.8	
27	80.8348	163.3319	80.3135	164.3218	−0.0071						
28	83.4971		84.0113			0.5213	0.5142	0.5178	0.5206	425.41	
	164.3326				0.0659						
					0.0481						
					.0014						

The solution was prepared in this case by adding 8 drops of c.p. conc: H_2SO_4 to the gallon of sol: The density of current was $\frac{426.8}{48}$ = 9 ampères approximately. The mean loss per plate was 0.002 gm the mean error 2.2%, the mean deviation 3.3 mgms from the mean and taking the plates 25 to 26 of last test together with the results 25-26 27-28 in this, we have the constant 1.015

Trial of Ag_2S cut-outs for Municipal lamps.

Thin rolled strip of Ag_2S prepared by the action of H_2S on $AgNO_3$ and the precipitate fused in a crucible under hydrogen. The resistance of these strips is exceedingly high, to a p.d. of only 2 or few volts but breaks down very rapidly under either heat or e.m.f. say of 100 volts. These cut outs seem to take practically no current from municipal lamps when used as shunts.

Carrying Capacity of Conductors.

Wires tested #10 bare soft copper Schenectady wire 0·13145" 613 cmm. 0·3416 cmm
#8 - - - - - 0·16142" 0·4170

Res: of galv: 5415 ω T.B. 22·5°C. = 2705 ω on each side ~~TTT~~.
Both halves of grating in parallel = 0·01225 ω.

No of Obs	Time	L.A. Ammeter	Amperes	Potentio Rdg	Amperes	Mean Potentio Rdg.	16·33 Amperes	Res: in cct with grating	Total Res: in cct with grating	3273 Total Res in #8 wire	R/r	Rise Temp.
1	16 49/55					0·0752	12·28	14·00	4105	0·088070		
2	16 57/100					0·12024	19·65	1397	4102	0·088076	1·001	-
3	17 57/70					0·1900	31·02	1370	4075	0·088130	1·0072	1·85
4	·18/20	6·75	47·	0·3112	50·8	0·3132	51·14	1195	3900	0·085498	1·053	13·6
5	·30/20	8·7	64	0·44293	71·73	0·44413	72·05	905	3610	0·079178	1·137	25·3
6	·30/20	10·15	77	0·5555	90·68	0·5517	90·66	660	3365	0·078245	1·220	36·55
7	·48/30	13·9	126	0·7716	126·0	0·7709	125·5	60	2765	0·07198	1·485	124·7
8												

No of Obs	Res: in cct with grating	Total Res: in #8 wire	Res: of #10 wire	R/r	Rise of Temp °C	Temp in	Rise of #10 wire	Rise of #8 wire	Res: of #10 @ 0°C.	Res: of #8 @ 0°C.	Sp. res	
1	-2·5	2680	0·01214			25°			25 × 0·014 = 0·1		0·01103 × 0·0426 = 613	0·0426 × 613
2	-7	2698	0·01222	1·007	1·8	0·1	1·7	2·7	0·01214 + 0·1	0·0080704		
3	35	2740	0·01241	1·022	5·66	0·2	5·6	3·0 1·8	= 0·01103	= 0·007336	= 16148	1628
4	277	2982	0·01350	1·112	28·8	0·3	28·6	2·1 13·3				
5	647	3552	0·01609	1·325	83·55	0·4	83·3	2·1 34·8				
6	1060	3765	0·01705	1·404	103·9	25·6	103·4	2·1 56·				
7	-	-						124·				
8												

Comparison of the two standard meters before sending them to Paterson N.J. 14th June 82

Res: both cils galv 5415 ω @ 22·5°C.

Temp. std copy 0·1 C.w. @ 25·5°C.

Res: added to std: side 20 ω. for 0·09945 meter shunt = 0·09925 × 0·10015 ω
- - - - - 10 ω. . 0·09980 - - 0·09963 × 0·10015 ω

= 0·09944 ω and 0·09978 ω respectively.
difference of 5 and 2 parts in 10,000 ω.

Res: of 0·09945 spool = 97·88 ω
- - 0·09980 . = 98·33 ω @ 22·5°C T.B.

On the specific resistance of metals.

Kemper in his Handbook of Elec. Testing 4th Ed p 4114 states that on the authority of Matthiessen the res: of a pure copper wire rises with the temperature according to the compound interest law: i.e. logarithmically. This statement does not seem to be borne out on an examination of Matthiessen's publications for on page 25 Phil Trans 1862 part 1 Table XII there appear the final values for the rise in res: of four copper wires –

0°C	100
20°C.	107.97
40°	116.33
60	124.98
80°	133.69
100°	142.22

If the logarithmic law held, taking $\log 1.0797 = 0.03330 \times 5 = 0.01665 = \log 146.72$. a very decided discrepancy in excess

But if $r = x + yt + zt^2$

$$\frac{dr}{dt} = y + 2zt$$

from this $y = 0.003955$ and $z = 0.000\,001\,481$

With the formula $r = x + 0.003955t + 0.000\,001\,481\,t^2$

we have @ −100°C $\frac{dr}{dt} = 0.003955 - 0.000296 = 0.003659$

" " @ 0°C $\frac{dr}{dt} = 0.003955$

" " @ 100°C " $= 0.003955 + 0.000296 = 0.004251$

" " @ 200°C $= 0.003955 + 0.00296 = 0.006915$

For this treatment of the problem the curve of res as ordinate to temp: as abscissa is always rising convex to the temp. but with Matthiessen's general equation $\lambda = 99.137 - 0.37675t + 0.000\,017\,456t^2$

$$\frac{d\lambda}{dt} = -0.37675 + 0.000\,017\,456\,t \quad \therefore \text{ when } t = \frac{.37675}{.000\,017\,456} = \frac{3.765 \times 10^{-1}}{1.746 \times 10^{-5}} = 215.7$$

λ is a minimum and again increases

or taking even $\lambda = 99.137 - 0.39201\,t + 0.000\,123\,18t^2 - 0.000\,000\,193\,t^3$

then λ = conductivity $\frac{d\lambda}{dt} = -0.39201 + 0.000\,246\,36t - 0.000\,000\,579\,t^2$

when $t = 314.5$°C a similar inflection takes place.

Judging from Dr Siemens' experimental results these final conductivity formulae are inadequate to express the general law. Taking Siemens' law for copper

$$r = 0.026577\sqrt{T} + 0.003\,144\,43\,T - 0.29751$$

we have $\frac{dr}{dt} = 0.089331\sqrt{T} + 0.010569\,T - 1$ as simplified from

and $\frac{dr}{dt} = 0.012\,8885\,T^{-\frac{1}{2}} + 0.003\,144\,43$

$$\frac{d^2r}{dt^2} = -0.006\,644\,43\,T^{-\frac{3}{2}}$$

for $T = 274$	$t = 0$	$\frac{dr}{dt} = 0.003\,989$	Mean 0° to 100°	0.00389
" $T = 374$	$t = 100$	$= 0.00383$		
" $T = 216$	$t = -58$	$= 0.004\,07$	" 0° to −58°	0.1400 given by 8.18 = 0.1415
" $T = 205$	$t = -69$	$= 0.004\,07$	" −69 to −123	0.415 given by 2.18 = 0.425
" $T = 151$	$t = -123$	$= 0.004\,22$		

Siemens' formula agrees with Matthiessen well + with Bullett + Beaty very fairly.

For now Siemens' law is $r = 0.072545\,T^{\frac{1}{2}} + 0.003\,8133\,T - 1.23971$

$$\frac{dr}{dt} = 0.02926\,T^{-\frac{1}{2}} + 0.003076$$

for $T = 274$ $t = 0$ $\frac{dr}{dt} = 0.004\,84$

" $T = 182$ $t = -92$ " $= 0.005\,14$

mean calculated value for range +9 to −92 = 0.489

Bullett + Beaty gui = 0.490.

Calibration of an Ammeter for Alternating Currents.

Received on the 15th June from Messrs Bergmann & Co. an ammeter without scale for calibration with alternating current of 200 to 300 alternations per sec.. The speed of the dynamo was 2160 revs per min = 35.8 × 8 = 286.4 alts per sec.

Calibrated the Cardew voltmeter as follows:—

Degrees	25	30	35	40	45	50	55	60	65	70	75	80
Volts	39.19	43.36	45.65	50.40	55.16	57.90	59.30	63.70	67.39	70.33	72.80	76.35
Δv / $\Delta\theta$		0.834	0.46	0.95	0.95	0.75	0.28	0.88	0.74	0.59	0.50	0.71
85	90	95	100	105	110	115	120	125	130	135	140	145
79.41	82.37	85.42	88.52	91.75	94.30	97.38	101.00	104.00	105.92	109.56	112.12	114.62
0.61	0.40	0.61	0.62	0.65	0.57	0.62	0.72	0.60	0.38	0.73	0.52	0.50

Stretched some 234.00 cms of thin platinoid wire 0.012" = 0.031 cm having a bot res: of 126.4 ω in five lengths up and down the 600 cm bench and with the ammeter in cct: observed the volts p.d. on this and other known resistances of 60, 90, & 120 ω also 1000 & 500 ω in a res: box... 10% being deducted from the cardew reading gave the mean emf in volts on the wire and this divided by the res gave the current. Several different readings on different resistances agreed very fairly.

After calibrating the scale from 0, 0.05, 0.1 to 1.45 in hundredths found that a current of 0.5 amperes continuous gave a reading of 0.2375 and a current of 1.0 ampere a reading of 0.87

Res: of apparatus about 1.9 ω

Comparison of resistances. 18th June. Differential Galvo:

Res: of Galvo 2702 + 27 × 0.03 × 5 = 2706 T.G. 24.2°.

Std. Legal Ohm @ 23.9° C correct at 15.5 = 8.4 × 0.0003 = 0.0025 ω.

Res: added to 0.1 ω 900 when 9000 : $\frac{1000 \times 2706}{2706}$ :: 9000 : 720.2 = 0.0252 ω equiv.

$\frac{0.00252 \times 3606}{2706}$ = 0.10002 ω @ 23.5° C.

With another 1000 obtained balance at 897 and a third 898 taking latter we have 0.1002 ω @ 23.5° C. = 0.1000 @ 15° C.

with legal Ohm and Copy) 0.01 ω Balance at 4.0 ω with 9900 : $\frac{100 \times 2706}{2706}$ results in 9900 : 96.43 :: $\frac{1.0025 \times 96.43}{9996.43}$ = 0.009672 equivalent

$\frac{0.009672 \times 2706}{2700}$ = 0.009836 ω @ 23.5° C.

With 0.1 and 0.01 copies added res: to 0.01 830 ω. } Wt 2 } 0.009833 @ 23.5°C. Wt

$\frac{0.1002 \times 730.2}{9730.2}$ = $\frac{0.00752 \times 3536}{2706}$ = 0.009826 ω @ 23.5°

With 0.01 and grating balance 615 ω on grating

$\frac{0.009833 \times 33.19}{2706}$ = 0.012006 ω

With 0.01 ω and large shunt for 1000 ampere balance 13750 ω on 0.01 ω

$\frac{0.009833 \times 2706}{16652}$ = 0.001615 ω } Wt 2 } 0.001627 Wt 1

With grating and large shunt balance 17030 on grating

$\frac{0.009833 \times}{0.012006 \times 2702}$ = $\frac{0.012006 \times 2702}{17732}$ = 0.001651

Carrying Capacity of Conductors.

June 15th Saturday)
2 samples of bare copper wire from Schenectady)
#6 BWG 0.203" by micrometer 1.5[illegible]ohm
#4 BWG 0.239" " " 1.97[illegible]-1.60)
Res. of grating 0.0121 " Res. galv 2735

Test No.	Time	Ammeter	Amperes	Potentiometer	Amperes	15.5 Mean Potentiometer Reading	Amperes	Res. in cct with grating #6	Total Res. for grating side	22.5 Res. of #6 6	$\frac{R}{r}$ #6
1	$10\frac{25}{40}$					0.0362	5.983	3870	6605	0.00501	1.000
2	$\frac{15}{30}$					0.0634	10.480	3800	6535	0.005063	1.0105
3	$\frac{20}{30}$	2.80	24	0.1577	26.06	0.1600	26.444	3705	6440	0.005139	1.0260
4	$\frac{15}{40}$	5.35	37	0.2512	41.52	0.2535	41.90	3585	6320	0.005226	1.0145
5	$\frac{45}{50}$	7.2	51	0.3439	56.85	0.3356	55.47	3430	6165	0.005367	1.071
6	$11\frac{50}{100}$	9.05	67	0.4386	72.50	0.4411	72.89	3190	5925	0.005581	1.114
7	$\frac{55}{70}$	10.10	77	0.5150	85.12	0.5110	84.20	3070	5745	0.005760	1.150
8	$\frac{45}{50}$	11.55	95	0.6200	102.2	0.6311	104.30	2700	5435	0.006059	1.215
9	$\frac{30}{50}$	12.55	107	0.7072	116.9	0.7191	118.85	2415	5150	0.006425	1.282
10	$\frac{30}{40}$	13.80	125	0.8160	134.9	0.8196	135.5	2040	#775	0.006920	1.383
11	$\frac{55}{55}$	14.60	132	0.9010	148.9	0.9394	155.3	1620	4355	0.007600	1.577
12	$11\frac{50}{12.00}$	15.9	158	1.0396	171.8	1.0586	173.6	1210	3945	0.008389	1.674

No. of Obs.	Res. in cct with grating	Total Res. grating side	Res. of #4	$\frac{R}{r}$ #4	Rise of temp. of #6	Rise of temp. of #4	Temp. air	Rise of #6	Rise of #4		
1	6370	9105	0.003627	1.			27°				
2	6285	9020	0.003668	1.011	2.70	2.83		2.7	2.8		
3	6130	8865	0.003733	1.029	6.68	7.45		6.7	7.5		
4	6030	8765	0.003776	1.041	11.57	10.54		11.6	10.5		
5	5890	8625	0.003837	1.058	18.25	14.91		18.3	14.9		
6	5770	8405	0.003938	1.086	29.3	22.11		29.3	22.11		
7	5470	8205	0.004033	1.112	38.56	28.79		38.6	28.8		
8	5190	7925	0.004176	1.151	55.27	38.82		55.3	38.8		
9	4865	7600	0.004357	1.200	72.50	51.41		72.5	51.4		
10	4500	7235	0.004574	1.261	98.46	67.09		98.5	67.1		
11	4020	6755	0.004899	1.351	132.9	90.21		132.9	90.2		
12	3600	6335	0.005224	1.440	173.2	113.1	27°	173.2	113.1		

$$a = \frac{-0.2 + 2.5 + 0.6}{n} \quad \frac{+0.85}{20} = \pm 0.0425$$

Division	Correction
0°	-0.2
5°	$-0.2 = (-0.02) + 0.0425 = -0.1375$
10°	$+0.085 - 0.2 + (-0.01) = -0.20 + 0.075 = -0.125$
15°	$+0.1275 - 0.2 - (-0.01) = -0.200 + 0.0375 = -0.0625$
20°	$+0.1700 - 0.2 - (+0.06) = -0.26 + 0.17 = -0.09$
25°	$+0.2125 - 0.2 - (+0.11) = -0.31 + 0.2125 = -0.0975$
30°	$+0.2550 - 0.2 - (+0.07) = -0.27 + 0.2550 = -0.015$
35°	$+0.2975 - 0.2 - (+0.09) = -0.29 + 0.2975 = +0.0075$
40°	$+0.3400 - 0.2 - (+0.09) = -0.29 + 0.3400 = +0.0500$
45°	$+0.3825 - 0.2 - (\pm 0.09) = -0.29 + 0.3825 = +0.0925$
50°	$+0.4250 - 0.2 - (+0.12) = -0.32 + 0.4250 = +0.1050$
55°	$+0.4675 - 0.2 - (+0.10) = -0.30 + 0.4675 = +0.1675$
60°	$+0.5100 - 0.2 - (+0.10) = -0.30 + 0.5100 = +0.2100$
65°	$+0.5525 - 0.2 - (+0.10) = -0.30 + 0.5525 = +0.2525$
70°	$+0.5950 - 0.2 - (-0.03) = -0.2 + 0.5950 = +0.4250$
75°	$+0.6375 - 0.2 - (-0.04) = -0.2 + 0.6375 = +0.4375$
80°	$+0.6800 - 0.2 - (-0.02) = -0.2 + 0.7000 = +0.5000$
85°	$+0.7225 - 0.2 - (+0.03) = -0.23 + 0.7225 = +0.5000$
90°	$+0.7650 - 0.2 - (+0.02) = -0.22 + 0.7650 = +0.5450$
95°	$+0.8075 - 0.2 - (+0.02) = -0.22 + 0.8075 = +0.5875$
100°	$+0.8425 - 0.2 - (+0.05) = -0.25 + 0.8425 = +0.5925$

Calibration of Standard Thermometer.

Inserted Standard Thermometers #1 and 2 also the three other Fahr Thermometers #3 4 + 5 in crushed ice that had been washed with tap water.

#1 and 2	indicated	0.1 +
#3	-	0.5°F +
#4	-	2.0°F +
#5	-	0.5 F +.

Upper end of thread	Lower end of thread	Difference	δ	Upper end	Lower end	Difference	δ	Upper end	Lower end	Difference	δ
105°	99.62	5.38	−0.02	70.01	64.74	5.27	−0.13	35.08	29.66	5.42	±0.02
100.00	94.60	5.43	+0.03	65.00	59.60	5.40	±0.0	29.90	24.54	5.36	−0.04
95.02	88.62	5.40	±0.	59.92	54.52	5.40	±0.0	25.05	19.60	5.45	+0.05
90.00	84.61	5.39	−0.01	54.98	49.60	5.38	−0.2	19.89	14.42	5.47	+0.07
84.93	79.48	5.45	+0.05	49.93	44.50	5.43	+0.03	14.90	9.50	5.40	±0.0
80.05	74.61	5.44	+0.04	45.01	39.61	5.40	±0.0	10.10	4.69	5.41	+0.01
74.96	69.59	5.37	−0.03	40.00	34.60	5.40	±0.0	4.73	−0.65	5.38	−0.02
			+0.16				−0.12				+0.09

Calibrated as above with a thread about 5.4 divs: long and using a slip of mirror behind thermometer to avoid parallax.

On the 10th Apr: 1890, the boiling point was found to be at 99.4° (corrected). and on the 3rd March, the zero was found to be 0.2.

From these data we have the following results tabulated for reference

Thermometer Reading.	Correction additive to reading.
0	−0.2
5	−0.14
10	−0.11
15	−0.06
20	−0.09
25	−0.10
30	−0.02
35	+0.01
40	+0.05
45	+0.09
50	+0.11
55	+0.17
60	+0.21
65	+0.25
70	+0.43
75	+0.50
80	+0.50
85	+0.50
90	+0.55
95	+0.59
100	+0.59

Meter Test.

Measurement of the resistance of the new bottle.

The test detailed on page 124 was recommenced at 8.7 VI 89. The solution was made on this occasion very slightly acid (a drop) and the temperature was maintained by thermostat. In the hot box it was 32·2°C (90°F) and in the refrigerator 45°F (7·2°C). Owing however to the failure on some days to keep the temperature at this low point the average temp: in the refrigerator may be estimated at (46°F)-(7·7°C). The current was maintained for four hours daily at 8 milliampères to represent as fairly as possible practical working conditions on full load. The total number of hours work was by account 41.

The plates were set in the bottle on the 8th June to that they were immersed 15 days.

No. of plate	Weight of empty 4. VI. 89	Gain Sample weight 4. VI. 89	Sum.	Weight empty 19. VI. 89	Observed Sample weight 19. VI. 89	Sum.	Sample gain	Mean plate gain	Plate gain	Plate loss.
1	54·4635	109·156	109·156	54·5716	109·1600	109·1616	0·0056	0·003	0·4366	0·4310
2	54·7321			54·2900						
3	55·2341	108·385	108·385	55·6637	108·3896	108·3898	0·0038	0·002	0·4297	0·4249
4	53·1511			52·7261						
5	52·6931	106·868	106·868	52·9000	106·871	106·8717	0·0037	0·002	0·2580	0·2543
6	54·1756			53·9717						
7	49·6758	104·109	104·105	49·4200	104·1154	104·1150	0·0070	0·004	0·2650	0·2580
8	54·4420			54·6950						
9	54·0795	110·912	110·912	55·9535	110·9196	110·9199	0·0079	0·004	0·2494	0·2415
10	56·8171			55·0664						
11	35·0355	88·7104	88·710	35·0050	81·7110	81·7109	0·0009	0·000	0·0209	0·0200
12	53·6755			53·7059						
13	54·9351	109·738	109·737	54·8300	109·7416	109·7410	0·0040	0·002	0·1250	0·1210
14	54·7965			54·9110						
15	52·3551	106·901	106·902	52·7350	106·9060	106·9072	0·0052	0·003	0·1282	0·1230
16	54·0544			54·1722						
								Mean		

No. of plate	Mean of gain 1 to 8	Accepted Total deposit gr	Res: of shunt observed	W-w	W-w / w	Res: of bottle	Mean Res: of bottle	Mean temp.	Diff res: per °C.
1 2	0·4338	0·4338							
3 4	0·4273								3·605w / 24·5 = 0·11472w
5 6	0·2562		2·07	0·1776	0·6932	1·4235	1·463	32·2°C 90°F	for 15·5°C 1·463 + 147 × 0·1472 = 1·463 + 2·187 = 3·92w
7 8	0·2615		2·07	0·1723	0·6589	1·3644			
9 10	0·2455		2·075	0·1883	0·7670	1·591			
11 12	0·0205		2·01	0 —	•				for 20°C. 1·463 + 12·32 × 0·1472 = 1·463 + 1·785 = 3·248w
13 14	0·1230		2·03	0·3108	2·527	5·120	5·068	7·7°C 46°F	
15 16	0·1256		2·02	0·3082	2·454	5·006			

Mr R. S. White in a letter of 11th June from Paterson N.J. gave the following results for normal temp. (say 20°C) by the same method.

#2 plate (same as our) japanned. solution sent from here neutral 1·110

	Res: No 1 pair	No 2 pair	No 3 pair
First trial 21 hour continuous run.	2·95	3·50	2·64
Second - 47 - - -	2·26	3·93	2·23

Mean of all 2·92w

- all but #2 pair 2·52w

Carrying Capacity of Conductors.

June 19th Thursday.

Wires tested #6 covered (white) copper wire from Bergmann & Co. 0·202" = 0·513
covered to 0·300 = 0·762
Schenectady 0·290" = 0·737

Res. of gal. #2 bare soft " " " 2120 cmils. cond. (assumed)

No. of Obs.	Time	Ammeter Rdg	Amperes	Potentio. Reading	Amperes K=5	Mean Potentio. Reading	Amperes	Res. in cct with #2	Total Res. for #2 cts.	Res. of wire	Res. in cct $\frac{R}{r}$	rise temp.
1	16.[illegible]					0·0766	12·66	1440	4160	0·002489	1·00	—
2	$\frac{\cdot 55}{20}$	1·9	20	0·12145	20·58	0·1251	20·68	1450	4170	0·002495	1·0022	0·57
3	$\frac{30}{20}$	5·0	35	0·22.14	36.60	0·2250	37.68	1475	4195	0·002509	1·0080	2·06
4	$\frac{35}{20}$	7.0	50	0·3182	52·59	0·3208	53·02	1510	4230	0·002531	1·0170	4·37
5	$\frac{40}{20}$	8.58	62	0·4186	67·70	0·4111	67·96	1560	4280	0·002560	1·0285	7·33
6	$\frac{50}{17.00}$	10·52	83	0·5635	93·20	0·5589	92·08	1670	4390	0·002626	1·0550	14·14
7	$\frac{55}{20}$	11·95	100	0·6600	109·1	0·6578	108·7	1780	4500	0·002692	1·0815	20·98
8	$\frac{60}{20}$	12·93	112·5	0·7522	124·3	0·7504	124·0	1870	4590	0·002746	1·1030	26·46
9	$\frac{70}{20}$	14·10	123	0·8749	144·6	0·8711	144·0	2055	4775	0·002857	1·148	38·04
10	$\frac{80}{20}$	14·78	140	0·9574	158·2	0·9577	158·3	2220	4940	0·002955	1·187	48·27
11	$\frac{90}{20}$	15·95	158	1·100	181·8	1·108	181·5	2435	5155	0·003084	1·239	61·44
12	$\frac{95}{18.00}$	16·90	176	1·220	207·7	1·235	207·1	2675	5195	0·003118	1·249	64·01

No. of Obs.	Res. in cct with #6 wire	Total res. in #6 cts.	Res. of wire	$\frac{R}{r}$	rise of temp.	Temp. of air.	°C. rise for #2 above air	°C. rise for #6 above air	res. of #2 @ 0°C	sp. cond.	res. of #6 @ 0°C	sp. cond.
1	6040	8760	0·005239			22°C.			0·002493	~~0·004825~~	0·004825	
2	6040	8760	0·005239	1·0		0·1	0·5			$\frac{2093 \times 4825}{613}$	$\frac{4825 \times 2.87}{613}$	
3	6160	8880	0·005312	1·014	3·60	0·2	1·04	3·4		= 1596	1627	
4	6285	9005	0·005386	1·028	7·20	0·3	1·1	6·9				
5	6485	9205	0·005506	1·051	13·11	0·4	6·9	12·7		98·5%	100·4%	100·4%
6	6985	9565	0·005720	1·092	23·65	0·5	13·6	23·2				
7	7090	9810	0·005868	1·120	30·85	0·6	20·4	30·3				
8	7650	10370	0·006203	1·184	47·30	0·7	25·8	46·6				
9	8300	11020	0·006590	1·258	66·33	0·8	37·2	65·5				
10	8900	11620	0·006950	1·327	84·07	0·9	47·2	83·2				
11	9980	12,600	0·007536	1·438	112·6	1·0	60·4	111·6				
12	10630	13350	0·007984	1·524	134·7	23·3	63·7	133·4				

L.R. Ammeter corrected for large discount in error

Carrying Capacity of Conductors.

June 21st Friday

Wires tested Black covered wire from Bergmann's drum 0.288" 0.7314 0.332 0.2778 approximately #22 B.W.G. covered to 0.363" 0.9220 0.393 0.9958 bared

No.	Time	L.R. Amm.	Amperes	Potentiometer Rdg.	Amperes	Mean Potentiometer Rdg.	Mean amperes	Res. in cct with small wire 2.720	Total res. in small wire cct.	Res. of small wire	$\frac{R}{r}$	Rise temp.
1	15.15				0.09240		0.09140	15.84	1650	4380	0.002610	
2	$\frac{30}{30}$	2.65	24	0.1500	24.80	0.1505	24.88	1655	4385	0.002613	1.001	0
3	$\frac{40}{40}$	5.72	40	0.2557	42.27	0.2536	41.93	1660	4390	0.002616	1.0022	0.5
4	$\frac{50}{50}$	7.7	57	0.3106	56.30	0.3122	56.56	1695	4425	0.002637	1.0105	2.7
5	$\frac{50}{16.00}$	9.6	74	0.4402	72.78	0.4401	72.76	1727	4457	0.002656	1.0175	4.5
6	$\frac{50}{10}$	10.75	85	0.5200	87.60	0.5298	87.58	1785	4515	0.002691	1.0310	8.0
7	$\frac{10}{20}$	12.1	101	0.6257	103.4	0.6252	103.3	1840	4575	0.002727	1.01150	11.67

No.	Res. in cct with large wire 2.720	Total res. in large wire cct	Res. of large wire	$\frac{R}{r}$	Rise of temp.	Temp. air	Rise of temp. in small wire	Rise of temp. in large wire	Res. of small wire at 0°C	% Conductivity	Res. of large wire at 0°C	% Cond.
1	710	3440	0.002054			25.5			18.69×10^{-3}	$\frac{1.46 \times 2.279}{613}$ 1620 resistivity	2.279×10^{-3}	
2	715	3445	0.002053	1.0015	0.2		0.0	0		107%	$\frac{2.279 \times 10^{-3} \times 1.62}{613}$ 1620 resistivity	
3	720	3450	0.002056	1.0032	0.8		0.5	0.5				100%
4	735	3465	0.002065	1.008	2.1		2.7	2.1				
5	755	3485	0.002077	1.0114	3.6		4.5	3.6				
6	782	3512	0.002093	1.021	5.4		8.0	5.4				
7	822	3552	0.002117	1.033	8.5		11.6	8.5				

The continuation of this test was prevented by the compound in the tube catching fire owing to a contact on putting a load in circuit with two small conductors.

June 24th Saturday

Carrying Capacity of Conductors.

(141)

Same wire as in the last interrupted test.

Black covered Benjamin's wire Diam. 0.288" taped to 0.343" No 2
0.7314 cm 0.8720 cm
0.322" leaded to 0.392
0.8178 " " 0.9958 No 1/2

No of obs.	Time	L.R. Ammeter Rdg.	Amperes	Potentio Rdg.	Amperes	Mean Potentio Rdg.	Mean Amperes	Res. in cut with 0.731	Total Res. in cut of 0.731 (2720)	Res. of 0.731	$\frac{A}{T}$	Rise of temp. °C
1	13.20	1.6	19	0.1229	20.31	0.1229	20.31	15.35	42.55	0.002539		
2	.35/50	E				0.1241	20.51	15.35	42.55			
3	.35/50	5.65	40	0.2502	41.36	0.2561	42.33	15.60	42.60	0.002528	1.0038	1°
4	.45/50	8.6	62	0.3912	64.66	0.3913	64.68	16.25	43.45	0.002559	1.0080	2.06
5	.50/14.00	10.4	81	0.5015	82.90	0.5020	83.00	16.95	44.15	0.002461	1.040	10.28
6	.50/75	11.42	92	0.5725	94.65	0.5698	94.20	17.60	44.80	0.002480	1.066	14.40
7	.50/30	13.65	123	0.7496	123.9	0.7493	123.8	18.85	46.05	0.002724	1.188	21.85
8	.35/30	15.0	142	0.8880	146.8	0.8882	146.8	20.25	47.45	0.002839	1.118	30.33
9	.35/40	16.16	163	1.0024	165.7	1.0050	166.1	22.15	49.35	0.003022	1.163	41.91
10	.50/50	17.25	186	1.1328	187.5	1.1290	186.6	23.02	51.02	0.003052	1.202	51.93
11	.50/16.00	18.75	218	1.2330	203.8	1.2352	204.1	25.75	52.95	0.003168	1.248	63.75
12	.50/50	19.57	232	1.3596	224.7	1.3482	222.9	28.00	55.20	0.003302	1.301	77.38
13	.35/35	20.40	251	1.4484	239.5	1.4458	241.0	30.30	57.50	0.003440	1.355	91.26
14	.35/65	21.4	275	1.6072	265.6	1.5935	263.7	33.30	60.50	0.003619	1.426	119.5

No. of Obs.	Res. in cut with 0.818	Total Res. in cut of 0.818 (2720)	Res. of 0.818	$\frac{A}{T}$	Rise of temp. °C	Temp. air °C	Rise of temp. cut 0.731	Rise of temp. cut 0.818	Res. of 0.731 @0°C	Conductivity %	Res. of 0.818 @0°C	Conductivity %
1	675	3395	0.002031			24.5°			0.002318		0.001852	
2	675	3395					1.0	1.50				1162.5/613
3	695	3415	0.002043	1.006	1.54					1588		1589
4	720	3440	0.002044	1.006	4.11		2.0	4.0				Mistake
5	755	3475	0.002079	1.024	6.17	.2	10.1	6.0				
6	795	3515	0.002103	1.036	9.26	.2	14.1	9.0		102.4%		102.4%
7	850	3570	0.002136	1.052	13.37	.4	21.5	13.0				
8	932	3652	0.002185	1.076	19.52	.5	29.9	19.0				
9	1027	3747	0.002242	1.104	26.74	.6	41.3	26.1				
10	1135	3855	0.002306	1.135	34.7	.7	51.2	34.0				
11	1247	3967	0.002373	1.169	43.44	.8	63.0	42.6				
12	1415	4135	0.002473	1.218	58.05	.9	76.5	55.2				
13	1545	4265	0.002552	1.257	66.06	1.0	90.3	66.0				
14	1745	4465	0.002671	1.315	81.00	25.5	109.5	80.0				

Res. of gauge 2720 ω each coil

Carrying Power of Conductors.

June 24th Monday
Wires tested as follow.
From Bergmann & Co Black covered wire diam 0.328" (0.825) covered (to pole) 0.425" 1.079
White - - - 0.340" (0.863) . braided . 0.466" 1.183

Res of yellow 2730 each coil

No.	Time	L.R. Ammeter	Amperes	Potentio Rdg.	Amperes	Mean Potentio Rdg.	Mean Amperes	Res in coil with 0.825 1.0714	Total Res in 1.079 coil	Res of 1.0714 0.825	R/T	Rise of temp
1	10.20	4.6	34	0.2060	34.05			620	3350	0.001997		
2	24/30			0.		0.2066	34.44	635	3365	0.002016	1.003	0.79
3	38/40	7.75	55	0.3394	56.10	0.3394	56.10	652	3382	0.002036	1.008	2.06
4	45/50	10.55	84	0.5002	82.66	0.4990	82.46	683	3413	0.002035	1.0775	4.50
5	55/60	12.8	110	0.6566	108.5	0.6578	108.7	735	3465	0.002066	1.0320	8.48
6	1.10/10	14.5	135	0.8055	133.1	0.8128	134.3	800	3530	0.002106	1.0580	13.37
7	15/20	16.5	168	0.9950	164.44	0.9936	164.2	914	3644	0.002172	1.0886	22.11
8	24/30	17.6	190	1.1200	185.1	1.1180	184.9	997	3727	0.002222	1.111	28.53
9	35/40	19.35	227	1.3528	223.6	1.3476	222.7	1175	3905	0.002328	1.164	42.16
10	45/50	21.1	267	1.5252	252.0	1.5818	257.5	1365	4095	0.002441	1.221	56.81
11	55/1.00	22.0	291	1.6590	274.2	1.6460	272.0	1570	4300	0.002563	1.282	72.50
								1620	4350	0.002593	1.297	76.34

No.	Res in coil with 0.863	Total res in 0.863 coil 2730	Res of 0.863	R/T	Rise of temp. °C	Temp air	Rise of temp coil 0.825	Rise of temp coil 0.863	Res of 0.825 @ 0°C	Conductivity γ	Res of 0.863 @ 0°C	Conductivity γ
1	395	3125	0.001863						0.001820		0.001716	
2	405	3135	0.001869	1.003	0.79	22°C	0.7	0.7		1210.58296 / 613		1266.55964 / 613
3	417	3147	0.001876	1.007	1.90	"	2.0	1.7		1605 resistivity		1637 resistivity
4	445	3175	0.001892	1.016	4.11	"	4.3	6.9		100.95		99.0
5	483	3213	0.001915	1.028	7.20	"	8.2	6.9				
6	540	3270	0.001949	1.046	11.82	"	13.0	11.4				
7	635	3365	0.002006	1.078	20.05	"	21.6	19.6				
8	714	3444	0.002051	1.101	25.96	"	27.9	25.4				
9	847	3577	0.002132	1.1444	37.02	"	41.5	36.3				
10	1005	3735	0.002226	1.195	50.13	"	56.0	49.3				
11	1140	3870	0.002307	1.225	61.44	"	71.6	60.5				
	1190	3920	0.002336	1.254	65.28	23°C	75.3	64.3				

Carrying Power of Conductors.

24th June Monday

Wire tested as follows

From Bergmann & Co black covered wire drawn: 0.364" (0.9244) taped to 0.460" (1.168)

" " " " 0.4455" (1.131) braided 0.550" (1.397)

Res: of galvo coils 2730 each side

No Obs	Time	L.R. Ammeter	Amperes	Potentio Rdg.	Amperes	Mean Potentio Rdg.	Mean Amperes	Res: in cct with 0.9244	Total res in 0.9244 cct	Res: of 0.9244	A/T	Rise of temp
1	16.20	4.2	31	0.1908	31.54	—		19 ~~1.908~~ ~~0.1908~~	27.19	0.001638		
2	20/20	4.2	31	0.1909	31.54	0.1904	31.48					
3	30/30	5.8	55	0.3629	56.36	0.3396	56.110					
4	40/40	10.9	86	0.5020	83.00	0.5033	83.20					
5	50/15.00	12.9	112	0.6602	109.1	0.6574	108.6					
6	60/10	14.8	140	0.8088	132.2	0.8076	132.5					
7	70/20	16.6	171	0.9984	164.0	0.9946	164.14					
8	80/30	18.1	200	1.2580	207.9	1.2520	207.0					
9	90/40	20.8	260	1.4464	239.0	1.4459	239.0	350	3480	0.001935	1.120	30.01
10	100/50	22.8	285	1.5936	263.5	1.6152	267.0	475	3205	0.001910	1.166	42.68
11	110/60	22.6	306	1.7750	293.14	1.7616	291.2	590	3320	0.001979	1.208	52.48
12	120/70	23.1	320	1.8784	307.3	1.8314	302.7	709	3439	0.002050	1.252	64.79

No of Obs	Res: in cct with temp not the	Total res in 0.9244 cct.	Res: of 1.131	A/T	Rise of temp °C	Temp: of air	Res: of temp cct 0.9244	Res: of temp cct 1.131	Res: of 0.9244 @ 0°C	% Conductivity	Res: of 0.131 @ 0°C	% Cond.
1	1300	4020	0.001102			23°C.			0.001504	150 x 4020 / 613	0.001112	100 x temp / 60
2	1300	4030	0.001102			81						
3	1297	4027	0.001103	1.001	0	82		5		164.3		165.6
4	1285	4015	0.001106	1.005	1.25	0.5	0	0.4				
5	1265	3995	0.001112	1.011	2.83	0.7		2.1		96.6%		97.0
6	1235	3965	0.001120	1.018	4.63	0.9		3.7				
7	1192	3927	0.001131	1.028	7.20	1.1		6.1				
8	1122	3852	0.001153	1.048	12.30	1.3		11.0				
9	1027	3757	0.001182	1.074	19.02	1.5	29.3	17.5				
10	955	3685	0.001205	1.095	24.42	1.7	41.	22.7				
11	852	3582	0.001240	1.127	32.65	1.9	51.7	30.9				
12	780	3510	0.001266	1.151	39.8	1.9	62.9	36.9				
						25°C						

Meter Test.

Took a test to obtain the res. of the meter bottle at ordinary temperatures. Six couples were weighed and set up on the 21st June. The current was started at 3 ampe. at noon and continued for 92 hours until 8 o'clock 25th June. The mean temp during the interval was about 75°.5 or 24°.C. The solution was similar to that used in the last test and was very slightly acid (4 drps) Four bottles were shunted by two shunt coils

No. of Couple	Weight 21.VI.89	Sum	Joint wt Ark	Weight 25.VI.89	Sum	Joint WG Ark	Loss.	Gain	Mean	Couple gain	Plate gain
1 2	53·5189 54·7878	108·2767	107·2765	53·8203 54·4584	108·2787	108·2850	0·3424	0·3514	0·3469	0·0090	0·0015
3 4	51·5990 52·3129	103·9123	103·9110	51·9492 51·9650	103·9142	103·9136	0·3479	0·3498	0·3441	0·0019	0·001
5 6	52·3557 53·7582	106·1111	106·1100	52·3943 53·7206	106·1149	106·1142	0·0344	0·0384	0·0365	0·0038	0·002
7 8	54·9390 54·2165	109·1555	109·1555	54·9120 54·2493	109·1613	109·1607	0·0270	0·0328	0·0299	0·0058	0·003
9 20	55·6303 54·5510	110·1813	110·1810	55·6964 54·5766	109·1821	110·1830	0·0242	0·0250	0·0246	0·0017	0·001
13 14	54·4444 57·7495	112·1639	112·1632	54·4376 57·7423	109·1677	109·1674	0·0193	0·0231	0·0212	0·0038	0·002
										Mean	0·002

No. of Couple	Shunted by.	Resistance W	W − w	$\frac{W-w}{w}$
1 2	∞	0·31455		
3 4	∞			
5 6	2·07		0·2090	8·147
7 8	2·07		0·3156	10·52
9 20	2·07		0·3209	13·05
13 14	2·07		0·3243	15·30

From some cause not known, the results seem hopelessly wrong.

t	C°	Res: per cm.	Energy per cm.	$(1.0077)^t \times 0.05825$	$(1.0077^t - 1)$	Energy indicated per cm.	Energy converted
1	432.7	3.949×10^{-5}	1.709×10^{-2}				
7.5	1681	4.946×10^{-5}	6.800×10^{-2}		0.0445		
23.4	3468	4.290	1.488×10^{-1}		0.0135		
37.5	5358	4.590	2.440		0.0233		
61.2	7815	4.894	3.825		0.0417		
91.5	11300	5.236	5.824		0.0710		
114.7	13450	5.692	7.657		0.0980		
156.3	17680	6.324	1.118				
	22.940	6.324	1.451				

Carrying Capacity of Conductors.

(145)

A pair of posts 180 cms high were set about 620 cms apart just outside and in a line parallel to the galvanometer building. These carried each a cross arm at the top 300 cms long with five insulators in them at 30 cms distances apart. Nine wires were stretched parallel from between these cross arms from opposite insulators. These wires were as follows counting from outside in i.e. the building.

			Length cms	Drains: in cms	Drains: in cms	Condition	Area: sq. inch	Area: cm.	Sq. cms	Page
3/0 #2	No. 1		607	0.296	0.737	bare soft Schitz	0.0861	80,100	0.14266	139
#4	- 2		608	0.239	0.607	- - -	0.0249	57,100	0.2894	136
	- 3 -		610	0.203	0.516	- - -	0.0324	44,200	0.2091	136
#6	- 4	(1)	615	0.135	0.343	white cotton and by (0.163 / 0.152)	0.1143	17,230	0.0924	—
#10 - #8 -	- 5 -		617.5	0.163	0.414	black cotton to (0.328 / 0.324)	0.0209	26,600	0.1346	—
#12	- 6 -	(1)	615	0.110	0.279	bare soft Schitz	0.0095	12,100	0.0611	—
#10	- 7 -	(2)	617.5	0.1365	0.3416	- - -	0.0142	18,200	0.0960	133
#8	- 8	(2)	616	0.164	0.417	- - -	0.0211	26,900	0.1366	133
#6	- 9		613	0.202	0.513	white cotton to (0.302 / 0.297)	0.0320	40,600	0.2057	139

Cables were led out to these wires and the current led up and down. The P.D. was taken off by insulated wires attached close up to the insulators and led through the windows. The wires tested on the first day were #~~4~~ 6 7 + 8 that is #~~8~~10 8, 10, + 12. B.W.G. June 27th Thursday. The same connections as usual were employed, and the grating in multiple as the standard res: of 0.0121 ω. Res: of galv at start 2710 ω per coil

No. Obs.	Time.	C.R. Ammeter	Amperes	Potentio Rdg. 16.23	Amperes	Mean Potentio Rdg.	Mean Amperes	Res: in ct with #4	Total res in #4 ct	Res of #4	Temp	Rise Temp C°
				0.024	3.98	0.0241	3.98	2710	5420	0.0242	1.00	
1	15.20/20	1.90	20	0.1245	20.58	0.1260	20.83	2730	5460	0.02429	1.000	1.
2	.40/20	5.65	40	0.2470	40.82	0.2480	40.99	2764	5574	0.02489	1.029	7.5
3	.60/20	8.0	57	0.3516	58.12	0.3561	58.86	3200	5910	0.02639	1.091	23.4
4	16.00/80											
5	.00/73	9.5	72	0.4406	72.82	0.4427	73.17	3500	6210	0.02773	1.146	37.5
6	.55/22	11.0	87	0.5304	87.66	0.5347	88.38	4000	6710	0.02996	1.238	61.2
7	.33/32	12.5	107	0.6430	106.3	0.6420	106.3	4640	7350	0.03282	1.356	91.5
8	.18/20	13.3	117	0.6989	115.5	0.7097	115.8	5120	7840	0.03501	1.446	114.7
9	.40/80	15.0	143	0.8100	133.9	0.8031	132.7	6000	8710	0.03890	1.605	156.3
10	.32/17.00	15.6	153	0.8945	147.8	0.9161	151.4	-	-	-		
11	.22/15	16.2	164	1.0000	165.3	0.9838	162.6	-	-	-		
12	.55/36	17.4	186	1.0972	181.3	1.0972	181.3	-	-	-		

The day was sultry and cloudy with very little wind. The temp: was 28.2° in the shade dry bulb + 26.1° wet bulb. The readings were very unsteady and seemed to be affected by slight movement in the air

E	C^2	C. Arm 0.7761 Res: per cm.	Energy per cm.	Emissivity per sq. cm. Kaufmann	(1.0077^8) $\times 0.0625$	$(1.0077^t - 1)$	Energy radiated per linear cm.	Energy conducted per linear cm.
5.4	1681	2.913×10^{-5}	4.896×10^{-3}	0.02896		0.003	0.0026	0.02664
15.9	3469	3.030	1.051×10^{-1}	0.1051		0.0093	0.0082	0.0969
25.0	5358	3.133	1.679	0.1679		0.015	0.0132	0.1547
39.1	7815	3.285	2.646	0.2646		0.02442	0.0212	0.2434
59.9	11300	3.519	3.977	0.3977		0.02424	0.0354	0.3623
80.5	13400	3.745	5.018	0.5018		0.060	0.0526	0.4492
110.5	17600	4.080	7.18×10^{-1}	0.7180		0.093	0.0815	0.6265
		0.9465						
3.3	1681	2.006×10^{-5}	3.373×10^{-3}	0.03337		0.0023	0.0025	0.0312
13.1	3469	2.08	7.216	0.07222		0.0076	0.0082	0.0640
17.9	5358	2.18	1.135×10^{-1}	0.11135		0.0104	0.0112	0.1023
31.6	7815	2.223	1.738	0.1738		0.0191	0.0205	0.1533
47.0	11300	2.343	2.647	0.2647		0.0304	0.0326	0.2324
56.8	13400	2.414	3.234	0.3234		0.0386	0.0414	0.2820
90.2	17600	2.674	4.706	0.4706		0.070	0.0751	0.3955
2.3	1681	1.395×10^{-5}	2.218×10^{-3}	0.0222		0.001	0.0013	0.0209
7.5	3469	1.346	4.67	0.0467		0.00444	0.0058	0.0409
9.5	5358	1.356	7.266	0.0727		0.0055	0.0072	0.0655
19.5	7815	1.407	1.099×10^{-1}	0.1099		0.0112	0.0147	0.0952
26.5	11300	1.442	1.630	0.1630		0.0158	0.0207	0.1423
32.7	13400	1.473	1.975	0.1975		0.020	0.0259	0.1716
49.9	17600	1.561	2.747	0.2747		0.033	0.0432	0.2315
79.5	22940	1.712	3.927	0.3927		0.059	0.0773	0.3154
83.0	26400	1.729	4.564	0.4564		0.0625	0.0819	0.3745
107.2	32800	1.853	6.077	0.6077		0.0892	0.1169	0.4908

Carrying Power of Conductors.

(146)

No. of Obs.	No. of wire	Diam: cms.	Res: in cct. with wire	Total res. in wire cct. 27°.0	Res: of wire	$\frac{R}{r}$	Rise of temp. above air	Rise of wire 100°	Absolute Conductivity	Cond: %	Amperes
1	6 #12	0.279	1220	3930	0.01755	1.00	0.26	0.01582	0.0152 $\frac{5.0641}{615.1572}$	97.0%	4
2			1225	3935	0.01757	1.001	0.26				20.8
3			1303	4013	0.01792	1.021	#54				41
4			1465	4175	0.01864	1.062	11.59				58.9
5			1605	4315	0.01927	1.098	21.50				73.2
6			1815	4525	0.02021	1.152	31.91				88.4
7			2135	4845	0.02164	1.233	51.99				106.3
8			2450	5160	0.02304	1.313	80.05				115.8
9			2910	5620	0.02509	1.430	110.5				132.7
10			3295	6005	0.02681	1.528	135.7				151.4
11			3700	6410	0.02862	1.631	162.2				162.6
12	–		4685	7395	0.03302	1.882	226.7				181.3
13											

No. of Obs.	No. of wire	Diam: cms.	Res: in cct. with wire	Total res. in wire cct.	Res: of wire	$\frac{R}{r}$	Rise of temp.	Amperes	Rise of wire 100°	conductivity	% Conductivity
1	7 #10	0.3416	30	2740	0.01223	1.00		4	0.01103	$\frac{1103 \times 0.0625}{617.5}$ $= .1786$	100.5%
2		0.073	35	2745	0.01226	1.0025	0.6	20.8			
3			64	2774	0.01239	1.013	3.34	41			
4			167	2877	0.01285	1.051	13.11	58.9			
5			220	2930	0.01308	1.0695	17.87	73.2			
6			365	3075	0.01373	1.123	31.62	88.4			
7			530	3240	0.01447	1.183	47.04	106.3			
8			635	3345	0.01494	1.221	56.81	115.8			
9			990	3700	0.01652	1.351	90.22	132.7			
10			1695	4305	0.01922	1.5722	147.1	151.4			
11			–								
12			–								

No. of Obs.	No. of wire	Diam cms.	Res: in cct. with plating 27°.0	Total res. in plating cct. 27°.0	Res: of wire	$\frac{R}{r}$	Rise of temp.	Amperes	Rise of wire 100°	conductivity	% conductivity
1	8 #8	0.417 0.310	1350	4070	0.008058	1.00		4	0.007268	$\frac{72268 \times 0.0625}{616.}$ $= 1.612$	100
2			1360	4070	0.008058	1.00		20.8			98.99
3			1325	4035	0.008128	1.009	2.3	41.			99%
4			1245	3955	0.007292	1.029	7.6	58.9			
5			1215	3925	0.008354	1.037	9.5	73.2			
6			1072	3782	0.007670	1.076	19.5	88.4			
7			980	3690	0.007886	1.103	26.5	106.3			
8			902	3612	0.007079	1.127	32.7	115.8			
9			700	3410	0.007618	1.194	49.9	132.7			
10			400	3110	0.01055	1.309	79.5	151.4			
11			367	3077	0.01066	1.323	83.0	162.6			
12			160	2870	0.01142	1.417	107.2	181.3			

Day Fine, but wires in shade. –

Res. of galv. at commencement 54.555 ω T.B. 24.8°C } 27.30 ω per unit
– close 54.20 ω 27.5°C

Temperature – commencement Dry 29° wet 24.4° galv. room 25°
– close 27.2 . 24.4 . 25°

Photographs taken of wires and poles

Readings unreliably from occasional gusts of wind, but day was fairly calm.

Circumference (mm)	Potential Temp	Current	C°	Res. per cm.	Energy per cm.	Radiation	Total radiation	Convection
2.315								
	5.9	155.4	24.150	4.274×10^{-4}	1.032×10^{-2}	0.003	0.0069	0.0063
	7.1	175.7	30.800	4.308	1.327	0.004	0.0093	0.0234
	12.3	202.3	40.900	4.395	1.798	0.007	0.0162	0.0136
	16.1	222.7	49.800	4.455	2.286	0.0095	0.0220	0.0186
	17.2	242.9	59.000	4.473	2.600	0.010	0.0232	0.0208
	23.1	268.5	72.000	4.571	3.292	0.0136	0.0315	0.0277
	41.1	292.5	85.500	4.863	4.161	0.0262	0.0607	0.3552
	46.8	300.1	90.000	4.955	4.460	0.0310	0.0718	0.3742
1.906	5.11	72.6	5271	6.376×10^{-4}	3.361×10^{-2}	0.003	0.00572	0.0279
	6.4	92.7	8593	6.406	5.504	0.0039	0.007743	0.0476
	7.5	114.4	13100	6.433	8.437	0.00444	0.00839	0.0759
	9.5	133.5	17800	6.483	1.154×10^{-1}	0.0055	0.010747	0.1049
	12.7	155.4	24150	6.552	1.585	0.007	0.013344	0.1452
	17.7	175.7	30870	6.675	2.061	0.003	0.01963	0.1865
	24.7	202.3	40900	6.902	2.823	0.016	0.030749	0.2518
	36.8	222.7	49500	7.148	3.538	0.023	0.043893	0.310
	37.5	242.9	59.000	7.166	4.228	0.0235	0.044478	0.378
	47.3	268.5	72.000	7.404	5.331	0.031	0.059054	0.474
	44.5	292.5	85500	7.334	6.272	0.029	0.05546	0.568
	52.4	300.1	90.000	7.524	6.771	0.035	0.06670	0.670
1.621	3.1	53.9	2905	8.762×10^{-4}	2.545×10^{-2}	0.002	0.0032	0.0223
	5.2	72.6	5271	8.936	4.710	0.0047	0.007612	0.0395
	9.3	92.7	8593	8.974	7.72	0.0051	0.008277	0.0688
	13.2	114.4	13100	9.102	1.192×10^{-1}	0.0075	0.01216	0.1070
	16.7	133.5	17800	9.226	1.642	0.0096	0.015576	0.1456
	23.7	155.4	24150	9.452	2.293	0.014	0.0227	0.2056
	31.9	175.7	30870	9.730	3.004	0.0196	0.0318	0.2686
	48.0	202.3	40.900	1.028×10^{-1}	4.313	0.031	0.0503	0.3840
	58.1	222.7	49.500	1.062	5.257	0.039	0.0632	0.4625
	67.6	242.9	59.000	1.094	6.454	0.0485	0.0778	0.5676
	84.6	268.5	72.000	1.151	8.288	0.064	0.1038	0.725
	164.8							
	185.9							

June 29th Friday

Carrying Power of Conductors.

(47)

No. of Obs.	Time	C.R. Ammeter	Amperes	Potentio Rdg	Amperes	(1.1) Mean Potentio Rdg	Mean amperes	Res. in cut with grating	Total res in grating cut	Res. of 1 unit	R/r	Rise temp.
1	11h 40					0.07145	12.31	10.320?				
2	50/15	4.0	29	0.1900	31.41	0.1899	31.39	10.245	12.975	0.002286		
3	55/15	7.4	53	0.3232	51.77	0.3258	53.85	10.175	12.905	0.002260	1.005	1.29
4	45/16	9.4	71	0.4400	72.73	0.4389	72.55	10.020	12.750	0.002291	1.018	1.46
5	25/25	11.5	94	0.5600	92.56	0.5611	92.74	10.050	12.780	0.002288	1.015	1.86
6	55/25	13.2	116	0.6925	114.5	0.6924	114.4	9.970	12.700	0.002560	1.022	5.66
7	25/16.10	14.6	136	0.8065	133.3	0.8078	133.5	10.060	12.790	0.002553	1.013	3.36
8	10/35	15.9	158	0.9425	155.4	0.9403	155.4	10.000	12.720	0.002595	1.0195	5.01
9	35/35	17.1	180	1.0600	175.2	1.0620	175.7	9.900	12.630	0.002615	1.0275	7.47
10	50/35	18.6	210	1.2020	198.7	1.2240	202.3	9.650	12.380	0.002688	1.056	12.34
11	20/17.10	19.5	230	1.3534	223.7	1.3476	222.7	9.480	12.210	0.002745	1.0587	16.12
12	35/25	20.1	244	1.4348	237.1	1.4496	242.9	9.420	12.160	0.002716	1.067	17.21
13	55/25	21.5	277	1.6260	268.7	1.6244	268.5	9.170	11.900	0.002776	1.090	23.46
14	15/27	22.7	310	1.7750	293.4	1.7694	292.5	8.860	11.590	0.002953	1.160	40.3
15	45/18.00	22.9	315	1.8216	301.2	1.8150	300.1	8.250	10.980	0.003008	1.182	46.98

$R_{20°C}$ of 0.002 $\frac{0.002 \times 0.0246}{0.07}$ = 1.411

79%

No. of Obs.	No. of wires	Diam. mm.	Res. in cut with grating	Total res in grating cut	Res. of wire	R/r	Rise of temp.	Amperes	Res. of wire @ 0°C	Conductivity	% Cond.
1	2	0.607	10.320								
2			5760	8690	0.003801	1.0			0.003828	$\frac{4.828 \times 2.54}{0.07}$	100.7
3			5905	8635	0.003826	1.0060	1.56	53.5		1632	
4			5790	8520	0.003877	1.020	5.14	72.6			
5			5750	8480	0.003895	1.025	6.43	92.7			
6			5715	8445	0.003911	1.029	7.45	114.4			
7			5650	8380	0.003942	1.037	9.51	133.5			
8			5550	8280	0.003989	1.0495	12.73	155.4			
9			5440	8140	0.004059	1.0690	17.74	175.7			
10			5140	7870	0.004197	1.1040	26.74	202.3			
11			4870	7600	0.004347	1.143	36.77	222.7			
12			4850	7580	0.004357	1.146	37.53	242.9			
13			4610	7340	0.004501	1.184	47.20	268.5			
14			3680	6410	0.004959	1.173	44.47	292.5			
15			3490	6220	0.004575	1.204	52.44	300.1			

No. of Obs.	No. of wires	Diam. mm.	Res. in cut with grating	Total res in grating cut	Res. of wire	R/r	Rise of temp.	Amperes	Res. of wire @ 0°C	Conductivity	% Cond.
1	3	0.516	3480?	6210?							
2			3325	6255	0.005282	1.			0.004763	$\frac{4.763 \times 2.54}{0.07}$	100.7
3			3250	6180	0.005315	1.012	3.08	53.9		1632	
4			3230	6060	0.005451	1.032	8.23	72.6			
5			3225	6035	0.005474	1.036	9.25	92.7			
6			3220	5950	0.005553	1.0515	13.24	114.4			
7			3240	5870	0.005627	1.065	16.91	133.5			
8			3090	5730	0.005766	1.092	23.65	155.4			
9			2884	5584	0.005936	1.124	31.97	175.7			
10			2540	5270	0.006268	1.1865	47.95	202.3			
11			2370	5100	0.006477	1.226	58.10	222.7			
12			2220	4950	0.006672	1.263	67.61	242.9			
13			1975	4705	0.007020	1.329	84.60	268.5			
14			1080	3810	0.008670	1.6411	164.18	292.5			
15			900	3630	0.009102	1.723	185.9	300.1			

Wire	Temp: elevation	C	C^2	Rec. per cm	Energy per cm	Radiation per sq cm	Total radiation per cm	Energy per cm	Convection
1.310	4.9	53.8	2905	1.329×10^{-4}	3.862×10^{-2}	0.003	0.0039	0.0386	0.0347
	14.14	72.6	5271	1.376	7.254	0.008	0.0705	0.0725	0.0620
	18.0	92.7	8593	1.395	1.199×10^{-1}	0.0105	0.0738	0.1199	0.1061
	28.3	114.4	13100	1.447	1.896	0.0155	0.0203	0.1896	0.1693
	41.9	133.5	17800	1.517	2.700	0.027	0.0354	0.2700	0.2366
	58.4	155.4	24150	1.601	3.867	0.0383	0.0502	0.3867	0.3365
	93.1	175.7	30870	1.776	5.482	0.073	0.0956	0.5482	0.4526

Carrying Power of Conductors.

No. of Obs	W	No. of wires	Diam. Diameter	Rec. Current with Heating	Rec. Current Rec. Current Square	Resistance Rec. per cm wire	R_t / T	Rise of temp	Amperes	Rec. of wire & o/o	Conductivity	f Conductivity
1	5	89	0.4144	1225?						0.007448	760×144 / 415	
2				1275	4005	0.008269						
3				1220	3950	0.008362	1.0114	3.60	53.8		1622	100.1
4				1100	3830	0.008625	1.0455	11.87	72.6			
5				1057	3787	0.008724	1.0575	14.78	92.7			
6				917	3647	0.009060	1.098	25.20	114.4			
7				802	3532	0.009362	1.138	34.31	133.5			
8				680	3410	0.009696	1.174	44.72	155.4			
9				465	3195	0.010334	1.253	65.04	175.7			
10				165	2895	0.011141	1.383	98.46	202.3			
11												
12												
13												
14												
15												

Short circuited

No. of Obs	W	No. of wires	Diam. Diameter	Rec. Current with Heating	Rec. Current Rec. Current Square	Resistance Rec. per cm wire	R_t / T	Rise of temp	Amperes	Rec. of wire & o/o	Conductivity	f Conductivity
1	8	89	0.417	1380	4090	0.008036				0.007248	724×144 / 414	
2				1360	4070	0.008075	1.045	1.29	31.4			
3				1305	4035	0.008180	1.079	4.89	53.8		1608	99.28
4				1165	3895	0.008480	1.055	14.14	72.6			
5				1112	3842	0.008597	1.070	18.0	92.7			
6				975	3705	0.008916	1.110	28.28	114.4			
7				805	3535	0.009363	1.163	41.9	133.5			
8				620	3350	0.009860	1.227	58.36	155.4			
9				290	3020	0.010940	1.362	93.06	175.7			
10				−100	2630	0.012560	1.561	144.2	202.3			
11												
12												
13												
14												
15												

Short circuited

No. of Obs	W	No. of wires	Diam. Diameter	Rec. Current with Heating	Rec. Current Rec. Current Square	Resistance Rec. per cm wire	R_t / T	Rise of temp	Amperes	Rec. of wire & o/o	Conductivity	f Conductivity
1	9	86	0.513	3400	6130	0.005389				0.004860	1460×267 / 613	
2				3387	6117	0.005406	1.002	0.5	31.4			
3				3355	6085	0.005458	1.007	1.8	53.8		1639	101.2
4				3245	5975	0.005639	1.026	6.68	72.6			
5				3200	5930	0.005709	1.033	8.48	92.7			
6				3110	5840	0.005856	1.0495	12.72	114.4			
7				3002	5732	0.005763	1.069	17.74	133.5			
8				2872	5602	0.005996	1.094	24.17	155.4			
9				2670	5400	0.006417	1.135	34.70	175.7			
10				2420	5160	0.006902	1.188	48.33	202.3			
11				2250	4980	0.006632	1.2305	59.26	227.7			
12				2092	4782	0.006990	1.295	75.84	242.9			
13				1940	4520	0.007367	1.356	91.52	268.5			
14				1745	4075	0.008196	1.504	129.6	292.5			
15				1120	3860	0.008660	1.588	151.2	304.1			

Meter Test.

The last test having given such anomalous results was repeated, under the same conditions. It commenced at 16.25.VI and ended at 9.29.VI., the current being maintained as before at 3 milliamperes. About 8½ hours in all. As in the previous case the bottle that took the whole current smutted. The mean temp. was about 24°C. Couple 3–4 was swapped to clean, all the varnish being removed.

No. of Bot.	Shunt	Weight 25th VI.	Observed empty weight	Sum.	Weight 29th VI.	Sum.	Loss	Gain	Mean Loss or gain	Gain per couple	Gain per bottle
1 / 2	∞	53.5895 / 54.0586	107.6483	107.6481	53.8654 / 53.7900	107.6554	0.2686	0.2759	0.2723	0.0073	0.004
3 / 4	2.06	51.5087 / 51.6790	103.1870	103.1877	51.6420 / 51.5508	103.1928	0.1282	0.1333	0.1308	0.0051	0.003
5 / 6	∞	52.2458 / 53.5990	105.8442	105.8448	52.5158 / 53.3360	105.8518	0.2630	0.2702	0.2666?	0.0072	0.004
7 / 8	2.06	54.7676 / 54.0791	108.8462	108.8467	54.8651 / 53.9850	108.8501	0.0941	0.0975	0.0958	0.0034	0.002
9 / 10	2.06	55.5043 / 54.4887	109.9930	109.9920	55.6018 / 54.3962	109.9980	0.0925	0.0975	0.0950	0.0050	0.003
11 / 12	~~2.06~~	54.4827 / 54.6023	109.0850	109.0835	54.4950 / 54.5362	109.0312	0.0726	0.0763	0.0745	0.0077	0.004
13 / 14	~~2.06~~										
											Mean 0.003

No. of Bot.	Average fill obs.	W − w	(W − w)/w	Rev. of bottle
1 / 2	0.2723			
3 / 4		0.1415	1.08	2.225
5 / 6		—		
7 / 8		0.1765	1.814	3.751
9 / 10		0.1779	1.82	3.75
11 / 12		0.1978	2.636	5.47

Observation on the Accuracy of the Barometer Scale.

June 29th Saturday

Mercury in reservoir of barometer cleaned. After the operation the distance between point and scale reading was observed by cathetometer as follows.

With one telescope only.

Reading of point 38.674
68 cm mark 106.620
67.946

38.674
of 26.75 mark 106.582
67.908

26.735 =
Error + 0.054 Error 0.015" in excess

With two telescopes

Reading of 100 mark Barometer 76.710
lower point 34.114
42.596 42.596

Reading of 26.75 mark 106.658
100 " 81.344
25.312 25.312

26.735 = 67.908
Error .015" per indication

The res: of field = $\frac{0.62 \times 3.0}{3.02} = \frac{1.86}{3.02} = 0.51$

" " armature = $\frac{0.3 \times 0.67}{0.97} = \frac{0.201}{0.97} = 0.21$

Res: of machine = 0.74 say 0.80 for margin

12 ampères being required from 120 volt @ M.T. = 30 ω

$\frac{30}{0.80}$ = 37.5 machines with no wire

Each mile of #12 copper wire BWG has a res: of 4.60 = 5% machine so that with one mile of this wire costing £314, 31 machines could be run.

Each mile of #9 copper wire BWG has a res: of abt 2.3 ω = 3 machine so that the wire cost being £68 (about) twice as long a it could be operated at ½ times the wire money

T. 7. 29.	Noon altitude	Sun's lower limit	71° 15′
	"	semi diameter	15.46
		altitude under	71° 30′ 46″
		refraction	26
		true alt:	71° 30′ 20.25
Decl: 9. noon 7. 7. 29		22. 33. 11	22. 18. 29.85
diff for 5 hrs		1.22	
		22. 31. 49	22. 31. 49
			45° 49′ 26″

The error of 15 miles due to twice error of pick prop making altitude too late.

Magnetometer Observations

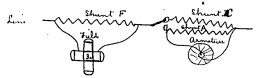
Set up portable magnetometer. Fixed the three main mirrors with their planes at right angles to within two or three minutes also measured the angles between the central clips as follows

Top + center 6° 30′
Centre + bottom 11° 48′

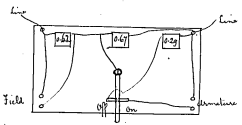
Set the screw of the magnet carriage correctly by ~~magnetometer~~.
Weight of brass cylinder 16.039 gms. Length 3.6 Diam 0.3235″ = 0.8215 cms

Phonograph Series Circuit Arrangement.

Theoretical connections



Practical connections



The exciting current is 4 ampères.

4 × 0.62 = 2.48 volts on the field. 4 × 0.50 = 2.00 on shunted field
4 × 0.67 = 2.61 " " armature 4 × 0.21 = 0.84 armature.
Res: of machine cut out 0.7 ω. current thro field = $\frac{4 \times 0.62}{2.32}$ = 1.17 amp
" " arm = $\frac{4 \times 0.67}{2.32}$ = 1.16.

Magnetic declination and Clock error observed at Eastern corner of Laboratory (Galv room) 7½ July 1889.

By first observation Magnetic declination 7° 30′ W.
second " " " 8° 35′ "
" third " " " 8° 35′ "

Time of third obs: by my watch 10 hr. 12 mins. Measured hour angle 97° 51′ 30″ − 70° 37′ 30″ = 27° 14′ = 1 hr. 48. 56.

True apparent time = 10. 11. 4

Correction to app: time for M.T. at 4 P.M. 282.0 cm
3 hours is 0.5 cm $\frac{1.5}{279.9}$

		4. 40	
True local mean time	10.	15	44
Long. W. of R. Ob.			4. 55. 52
" Greenwich	74° 13′ 30″	1. 00	4. 56. 52
True G.M. mean time	10.	16.	44
Watch showed	10	12.	00
Error of watch in excess		4. 44	
Astronomical clock by comparison with watch		1. 26	fast
Error of clock in excess		2. 18	slow but mine correctly keeping 18 sec error

h m s
1. 0

log 17·79 = 1·25018
2·50036
L tan 11°51′ = 9·32185
3·07239 = 1181·14

log 21·715 = 1·33676
2·67352
L tan 6°31′30″ = 9·05834
3·06862 = 1171·2 10·2

log 17·79 = 1·25018
L tan 11°51′ = 9·32185
0·57203 = 3·73·3

log 21·715 = 1·33676
L tan 6°31′30″ = 9·05834
0·39510 = 2·4844 1·249

P = 8·16 lb.

---

log 17·79 = 1·25018
1·25018
2·50036 = 316·5 − 8·2 = 308·3

log 308·3 = 2·48897
7·98861
= 7·79 = 1·25018
(17·79)² = 2·50036
L tan 11°51′ = 9·32185
13·06100 = 1151 ÷ 2 = 575·5

---

log 5·153 = 0·71206
1·42612 = 26·55
0·7965 × 17·88 = 14·24

log 7·735 = 0·88863
1·77726 = 59·88
26·55
33·33

$\frac{0·93}{402} = \frac{93 \times 10^{-2}}{402} = 2·314 \times 10^{-3} = 8' = \frac{5400}{5400} = 1·0015$

log 5·153 = 1·42612
1·0015 = 0·00065 1·42677
η^2 = 0·99232
μ = 0·60206
I = 1·18351
2·74987
MH = 1·32510 = 21·14

log $\frac{M}{H}$ = 2·76005
M^2 = 4·88515
M = 2·04259 = 110·3
H = 1·28252 = 0·192

L cos 81°27′ = 9·17223
log 2·5028 = 0·39843
9·37066 = ·3721

3·0 × 5·18 × 10⁻³ = 15·54 × 10⁻³ = ·0855
·3876

980·6056
·3876
980·218

Magnetometer Observations

On 11th pier cover with portable magnetometer. 6th July 89

The unloaded tubular magnet was observed with the aid of the chronograph to complete 65 period in 335 seconds = 5·153 sec. The torsion produced by $\frac{\pi}{2}$ twist was $\tan^{-1}\frac{0·03}{50} = 2'$. When loaded with a cylinder whose moment of inertia is known to be 17·88 cm²gm. the magnet completed 51 complete periods in 39 min 6 sec or = 7·735 secs per swing and the torsion produced by $\frac{\pi}{2}$ was $\tan^{-1}\frac{0·93}{402}$.

The deflection readings were for 11°48′ 17·69 + for 6°28′ 21·61
17·95 21·99
17·74 21·67
17·78 21·74
Means 17·79 21·715

The torsion was $\tan^{-1}\frac{1·42}{2}/230$ for $\frac{\pi}{2}$ = 0·00617 = 21′

The correction for these deflections is

$\varphi_1 = \frac{5400}{5400}\varphi = 1·002\varphi$. ∴ φ = 707′ and 390′
707·9 = 11·58′ 390·8 = 6°36′30″

$$p\,\frac{M}{H} = \frac{\frac{\pi^2}{2}(17·79^2)\tan 11°58' - \frac{\pi^2}{2}(21·715)^2\tan(6°36'30'')}{17·79\tan 11°58' - 21·715\tan(6°36'30'')} = 8·16$$

$$\frac{M}{H} = \frac{l}{2}(17·79)^2\tan 11°58'\left(1 - \frac{6·2}{17·79^2}\right) = 575·5$$

The moment of inertia of the magnet is

$$17·88\left(\frac{5·153^2}{7·735^2 - 5·153^2}\right) = 14·24 \text{ cm}^2\text{gm.}$$

The moment from the magnet's proper dimensions is 14·25

The corrected periodic time of the magnet is unloaded

$$t_1^2 = t^2\left(\frac{5400 + \theta}{5400}\right) \text{ where } \theta = \tan^{-1}\frac{0·93}{402} = 1·0015^2$$

$$MH = \frac{4\pi^2 I}{T^2} = \frac{4\pi^2 \times 14·24}{T^2} = 21·14.$$

∴ M = 110 and H = 0·192

Data

The elevation at which the laboratory stands above the mean level of the Atlantic from the county map in the hall of the Y.M.C.A. appears to be 170 feet = 5180 cm.
The latitude is approximately 40°43′30″ N
long. 4h 55m 52s W.

With these values g = 980·6056 − 2·5028 cos 81°27′ − 3·0 × 10⁻³ × 5·18 × 10⁻³

= 980·22

H = 0·192

15 · 29 · 12·6
− 24 · 00
5 · 12·6 = 312·6 ÷ 5·2 = 60 = 312 secs

15 · 32 · 41
29 · 12·6
3 · 25·4 = 205·4 ÷ 5·2 = 40 = 208 secs

Total number of vibs = 40 + 60 + 40 = 140

15 · 32 · 41
− 20 · 32
12 · 09 = 729 secs ÷ 140 = 5·207 secs

log 4 = 0·60206
π² = 0·99430
14·25 = 1·15381
2·75017

log 5·207 = 0·71659
0·71659
1·43318
1·43318
1·31699 = 20·75

17·80³ = 5639·75 log = 3·75126
L tan 11°48′ = 9·31996
3·07122 = 1178·2

3·25042
9·31996
0·57028

3·719
2·4844
1·235

(21·8)³ = 10360 log = 4·01536
L tan 6°30′ = 9·05666
3·07202 = 1180·4 / 1178·2 / 2·2

1·33846
9·05666
0·39512 2·484

2·2 ÷ 1·235 = 1·78

log 0·5 = T. 6989·7
− (17·80)³ = 3·75126
L tan 11°48′ = 9·31996
m/H = 2·77019

2·77019
log mH 1·31699
4·08718
m = 2·04359 110·56
7·27340 0·1877

Magnetometer
Observation in Llewellyn Park. 7th July 89.

Portable Magnetometer. Time 15·0. Temp. 32° C.

Deflection reading

17·89	21·74	
17·78	21·68	
17·73	21·76	
17·81	22·01	
17·80	21·80	angle 6°30′ 11°48′

Vibration reading

			Time	Period	
0	hemit +>	15 · 20 · 32			
10 lf	–	21 · 24·5	52·5	5·25	5·20
20 lf	.	22 · 15·25	54·75	5·075	
40 lf	.	24 · 00	104·75	5·238	
2 lf	. +→	29 · 12·6			
2+10 lf	–	30 · 05·8	53·2	5·32	5·20
2+20 lf	–	30 · 55·4	49·6	4·96	
2+40 lf	.	32 · 48·5	53·1	5·31	
2+80 lf	.	32 · 41	52·5	5·25	

From this series the period is 5·207 secs.
Shortly after loading the magnet the fibre broke.

$$M.H. = \frac{4\pi^2 \times 14{\cdot}25}{(5{\cdot}207)^2}$$

$$= 20{\cdot}75$$

$$P = \frac{(17{\cdot}80)^3 \tan 11^\circ 48' - (21{\cdot}80)^3 \tan 6^\circ 30'}{17{\cdot}80 \tan 11^\circ 48' - 21{\cdot}80 \tan 6^\circ 30'} = -1{\cdot}78 \text{ negligible}$$

$$\frac{m}{H} = \frac{1}{2}(17{\cdot}80)^3 \tan 11^\circ 48'$$

$$= 589{\cdot}1$$

$$m = 110{\cdot}56$$

$$H = 0{\cdot}1877$$

58 29 3202
48 76 1.3
3
93 [illegible] 26.86 = 2.335

Resistances of Plain Meter Plates at No. 2.

Edison Laboratory. – June 29. 1889.

		Out	In	Loss	Gain	per plate Gx.	d' Mean	r	r' = r d / d'
Hot 90°F	1	53825	53963		138	27	111	#1	
		54466	53982	84			122	2.023	R = 2.22
	2	54823	54713	110		20	130	#2	
		53908	53157		149		103	2.029	R = 1.61
32.2°C.	3	50540	50421	119		19	138	#3	
		52970	53126		156		95	2.023	R = 1.40
Cold An 47°F 8.3°C.	4	53643	53570	73		9	82	#4	
		51515	51605		90		121	2.052	R = 3.78
	5	51392	51325	87		2	69	#5	
		52960	53031		71		164	2.010	R = 4.78
	6	54976	54906	70		12	82	#6	
		54410	54504		94		151	1.990	R = 3.66
Ordinary An 75°F 24°C.	7	52946	53070		124	17	108	#7	
		55087	54996	91			125	2.012	R = 2.33
	8	54005	54121		116	14	103	#8	
		52677	52588	89			130	2.027	R = 2.06
Series in hot bath	9	53310	53571		261	25	236	Series	
		50572	50361	211			233		
	10	53250	53546		296	37	229	Series	
		53760	53568	192					

Test extended June 29 – July 10 11 days.

Solution neutral sp. gr. 1.11 mid cold. Hot amalgamation

A repetition of that given on page 114g. It was commenced on the morning of the 3rd July and continued until the 8th July, the total time of working being 109 hours. The current was approximately 3 milliampères and the solution 1.110 slightly acid (1½ drops). Six bottles were employed 3 shunted and three unshunted. The mean temp. was 74° F about or 23.3°C.

No. of plate	Shunt	Res. of shunt	Weight 2. III.	Complete Weight cold	Summ	Weight 8. III.	Complete Weight	Summ	Gain of complete	Gain per plate
1	∞		53.5172	106.6140	106.6143	53.2216	106.6157	106.6152	+0.0012	+0.0006
2			53.0971			53.3936				
3	∞		51.9351	103.5624	103.5661	52.2299		103.5653		
4			51.6310			51.3354			−0.0007	—
5	∞		51.5764	104.4200	104.4205	51.2913	104.4180	104.4184	−0.0016	−0.0008
6			52.8441			53.1371				
7	#4	2.06	53.9835	105.6740	105.6745	53.8500	105.6707	105.6702	−0.0038	−0.0019
8			51.6910			51.8202				
9	#10	2.06	54.2524	108.1158	108.1153	54.1170	108.1150	108.1148	−0.0001	−0.0005
10			53.8649			53.9978				
11	#12	2.06	54.1379	108.6603	108.6608	54.0129	108.6590	108.6592	−0.0011	−0.0006
12			54.5229			54.6463				
									Mean	−0.0005

No. of Plate	Gain	Loss	Mean Gain or Loss	Accepted Full Value W	W − w	(W − w)/w	Res. of bottle	Mean
1	0.2965		0.2961					
2		0.2956						
3	0.2948		0.2952	0.2951				
4		0.2956						
5	0.2930		0.2940					
6		0.2951						
7		0.1335	0.1334		0.1637	1.246	2.587	
8	0.1292							
9	0.1329	0.1334	0.1332		0.1619	1.215	2.503	2.635
10								
11	0.1264	0.1250	0.1242		0.1709	1.376	2.834	
12								

When $d = 0.3''$ $f(d)$ approximates by trial to $d^{\frac{1}{2}}$

$$\therefore \quad D \cdot 3 \left(\log_e \frac{D}{d}\right)^{-\frac{1}{2}} = 0.3^{\frac{1}{2}}$$

$$\therefore \quad \log_e \frac{D}{d} = 0.3^{\frac{1}{2}}$$

$$\log_e \frac{D}{d}^{-1} = 0.3444$$

$$\log_e \frac{D}{d} = 3.73$$

$$\log \frac{D}{d} = 1.669 \ * \qquad \frac{D}{d} = 28.06 \qquad D = 8.5$$

When $d = 0.1$ $\frac{D}{d} = 8.09$ $\log_{10} \frac{D}{d} = 1.9294$ $\log_e \frac{D}{d}$ 4.4444 $\left(\log_e \frac{D}{d}\right)^{\frac{1}{2}} = 2.114$ $\left(\log_e \frac{D}{d}\right)^{\frac{1}{2}} = 0.473$

$$d\left(\log_e \frac{D}{d}\right)^{-\frac{1}{2}} = 0.0474$$

When $d = 0.2$ $\frac{D}{d} = 12.8$ $\log_e \frac{D}{d} = 1.6294$ 3.75 1.94 0.516

$$d\left(\log_e \frac{D}{d}\right)^{-\frac{1}{2}} = 0.103$$

When $d = 0.3$ $\frac{D}{d} = 26.3$ 1.4519 & 3.3444 1.83 0.546

$$d\left(\log_e \frac{D}{d}\right)^{-\frac{1}{2}} = 0.164$$

When $d = 0.4$ $\frac{D}{d} = 21.25$ 1.327 3.056 1.75 0.571

$$d\left(\log_e \frac{D}{d}\right)^{-\frac{1}{2}} = 0.228$$

With these values and the curve for 20°C wires we have on looking 0.5" diam as standard

0.1"	Around	31	Calculated	140
0.2"	"	86	"	86.7
0.4"	"	216	"	192

Owing to the conductivity of air carrying into account (thermal) to different degrees with different wires, the formula cannot be expected in any case to apply rigorously

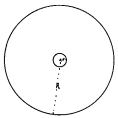
Magnetic Measurements

Made near Bechtelsville Berks Co. Pennsylvania July 89.

A magnet suspended by a fibre about its centre which made 50.5 complete swings in 5 mins in Shewellyn Park where the Horizontal component is 0.188 gave 51 complete swings in that time at some distance from disturbing forces near Gilbert's mine Pa. but in one place near the bottom of a shaft at the top of the same hill and right in the back of the magnetite bed it executed 121 complete swings in that time. The horizontal component at that spot in the mine must thus have been approximately $\left(\frac{121}{50.5}\right)^2 \times 0.188 = 1.080$

A dipping needle about 8 cms long and almost balanced when held vertically gave dip as high as 10° and in one or two instances even 25° in the neighborhood of ore.

The following problem presents itself in the preliminary mathematical investigation of the ∮ carrying capacity of moulded conductor.



Let a conductor of radius r be enveloped by a homogeneous cylindrical mass of radius R of non conducting material. Let a current c traverse the conductor until the permanent state is indefinitely closely approached. Let the exterior temperature of the envelope be τ. Required the interior temperature when k is the thermal conductivity of the envelope.

The energy developed per unit length of conductor is $\frac{c^2\rho}{\pi r^2}$ where ρ is the resistivity of the conductor and the heat developed in unit time is $\frac{c^2\rho}{J\pi r^2}$ therms.

At any distance σ from the centre let a circle be drawn and a cylinder of unit length erected on this circle. Then the heat escaping across this unit area of this cylinder in unit time is $-k\frac{d\theta}{d\sigma}$ and the total flux is thus $-\frac{2\pi k\sigma\, d\theta}{d\sigma}$

This must be the heat generated in the wire. Hence

$$\frac{c^2\rho}{J\pi r^2} = -2\pi k\, d\theta \frac{\sigma}{d\sigma}$$

$$\therefore \quad d\theta = \frac{-c^2\rho}{2Jk\pi^2 r^2} \frac{d\sigma}{\sigma}$$

$$\theta = \frac{-c^2\rho}{2Jk\pi^2 r^2} \times \log_e \sigma + a$$

when $\sigma = R$

$$\theta = \tau$$

$$\tau = \frac{+c^2\rho}{2Jk\pi^2 r^2} \times \log_e \frac{1}{R} + a$$

$$\therefore \quad \theta = \frac{c^2\rho}{2Jk\pi^2 r^2}\left(\log_e \frac{1}{r} - \log_e \frac{1}{R}\right) + \tau$$

$$= \frac{c^2\rho}{2Jk\pi^2 r^2}\left(\log_e \frac{R}{r}\right) + \tau$$

$$\theta - \tau = b\frac{c^2}{d^2} \log_e \frac{R}{d}$$

when $R = \infty$

$$\theta - \tau = b\frac{c^2}{d^2}\left(\log_e \frac{1}{d} - 1\right)$$

so that the rise of temperature would vary as the square of the current and nearly in inverse proportion to the square of the diameter for small wires

$$c^2 = \frac{\theta - \tau}{b}\left(\frac{d^2}{\log_e \frac{R}{d} - 1}\right)$$

$$c = \sqrt{\frac{\theta - \tau}{b}}\; d \times \left(\log_e \frac{R}{d}\right)^{-\frac{1}{2}}$$

July 17th Wednesday. **Physiological Experiments**

Took the following measurements of the resistance of different persons in the Laboratory under the following conditions. Two bichromate battery jars were nearly filled with a solution of $Zn\,SO_4$ and two more with solution of crude K.HO. The density of the $Zn\,SO_4$ solution was 1.120 - - - - - K.HO - 1.10

The hands after being washed were immersed vertically downwards into these jars until the tips of the fingers rested on the bottom. The surface of the liquid then reached about as far as the pulse of the wrists. The measurement was first made in $Zn\,SO_4$ and then in the K.HO with the hands washed between the tests. The Wheatstone's bridge and deadbeat galvanometer on the first table were used, with 4 Fuller cells 100/1000 and imp: z: observations. The results are thus independent practically speaking of polarization. The resistances were observed after about 30 seconds immersion but continued to reduce beyond that period.

No. of Obs.	Name	Age	Height	Weight lb	Resistance $Zn\,SO_4$	Resistance K.HO.	Difference	v = M − 905 K.HO	$\frac{\Sigma v \times 0.6745}{\sqrt{n(n-1)}}$	$\frac{0.6745\,\Sigma v}{\sqrt{n(n-1)}}$
1	Dean	42	5·2½	115½	1350	950	400	+ 45	22·1 ±	139 ±
2	Ott	39	5·4	142	1250	850	400	− 55		
3	Lehmann	20	5·3	138	1200	800	400	−105		
4	Lassetz	32	5·7	122	1250	920	330	+ 15		
5	Gogard	33	5·4	126	1220	870	350	− 35		
6	Kilpper	33	5·8½	156	1200	870	330	− 235		
7	Hiffle	34	5·5½	130	1470	820	650	− 95		
8	Schaffner	33½	5·9	146	1000	670	330	−235		
9	Heiser	41	5·5	180	1310	700	610	−205		
10	Miller	20	5·8	122	1090	880	210	− 25		
11	Aylworth	20	5·9½	139	1250	1000	250	+ 95		
12	Logue	42	5·7½	155½	1440	880	560	− 25		
13	Fox	29	5·6½	125	1710	1000	710	+ 95		
14	Rundlett	25	5·4	138	960	600	360	−305		
15	Dowell	22	5·4½	135	900	550	350	− 355		
16	McGinn	27	5·5	122	1430	870	560	− 35		
17	Whittemore	37	5·9	142	1240	650	590	−455		
18	Cobb	49	5·9½	147	1030	670	360	− 235		
19	Neubert	37	5·3½		1090	790	300	− 115		
20	Read	18	5·10	121	1170	1070	100	+ 165		
21	Huffmeier	25	5·10	126	1400	1000	400	+ 95		
22	Wesby	48	5·4	140	820	520	300	− 285		
23	Hastings	40	5·2	140	1520	1000	520	+ 95		
24	Dixon	30	5·10	137½	1460	1070	390	+ 165		
25	Brown	42	5·7	125	1470	1090	380	+ 185		
26	Rehr	48	5·4	141	1610	1250	360	+ 345		
27	Nickon	27	5·11½	140	1440	1130	310	+ 225		
28	Frickhow	23	5·9	137	1500	1170	330	+ 265		
29	Doehler	25	5·11½	132½	1280	1070	210	+ 165		
30	Rockwell	29	5·10	170	1370	960	410	+ 55		
31	Ott	38	5·5½	135	1800	1320	480	+ 415		
32	Lord	59	5·6½	150	1380	910	470	+ 5		
33	Donovan	20	5·7	144	1230	850	380	− 55		
34	Rotsbeter	43	5·4	130	1230	950	280	+ 45		
35	Dahl	35	5·9	147	1200	650	550	− 255		
36	McCrank	19	5·6	119	1350	920	430	+ 15		
37	Luddke	18	5·6	122	1650	1400	250	+ 495		
38	Magee	37	5·11½	156	1040	720	290	− 155		
39	Fessenden	22	6·0½	165	1220	1090	130	+ 185		
					50560	35370	15190	Σ v		
				Mean	1296	905	391	= 6325		
							of difference 30%	= 162 ± average discrepancy		
				Maximum	1800	1400				
				Minimum	820	520				

Physiological Experiments.

July 19th Friday

Took the Carpentier D'Arsonval galvanometer, and a Wheatstone Bridge ~~[illegible]~~ to the Phonograph Works and set them up in the Testing Room there. Used four phonograph cells of the chromic acid type. Filled up two tall and glass jars as in the preceding test with a solution of crude H_2O of density 1.10 and changed the solution in the afternoon. Each man washed his hands & dried them before immersing them ~~[illegible]~~ pointing vertically downward in the jars until the tips of the fingers rested on the bottom. The bridge ratio was 1000/100 no shunt capable of reading to single ohms and observation was made to one F.E. The current was applied on the average for about thirty seconds. The surface of the solution reached as a rule the pulse of the wrists.

No. of Obs.	Name	Age	Weight	Height	Res:	Variation from 1000	No. Volume 900 1100 ±15	
1	Osborne	25	143	5.10½	1170	170		
2	Ballins	33	148	5.7	930	70		
3	Barry	34	104	5.5½	1130	130		
4	Garcia	20	109	5.5½	1590	590		
5	Muchmore	29	123	5.6½	1090	90		
6	Richelton	45	137	5.8½	870	130		
7	Oxley	22	133	5.9½	980	20		
8	McNab	21	127	5.9	1060	60		
9	Thrige	23	125	5.7	1570	570		
10	Sandford	51	200	5.7	660	340		
11	Smith	33	175	5.11	840	160		
12	Gandegger	20	150	5.11	900	100		
13	Jaeger	22	136	5.10	1120	120		
14	Archer	22	112	5.6	1160	160		
15	Barne	20	122	5.9	1000	0		
16	Wagner	27	123	5.8½	1160	160		
17	Jordon	34	122	5.7	1030	30		
18	Tremayne	19	150	5.10	1050	50		
19	Bonett	28	138	5.4	1010	10		
20	Gadetten	21	146	5.10½	950	50		
21	Owen	19	122	5.8	1160	160		
22	Payne	21	121	5.10½	1230	230		
23	Mike	34	160	5.9	960	40		
24	Pixley	20	151	5.9½	1080	80		
25	Sandford	28	132	5.5½	990	10		
26	Van Halfen	28	139	5.5½	980	20		
27	Nelson	19	119	5.6	1010	10		
28	Francisco	22	131	5.9½	1000	0		
29	Thurman	20	118	5.10	1400	400		
30	Wagner	29	121	5.8	1110	110		
31	Harris	20	137	5.11	1310	310		
32	Miller	20	159	6.2⅞	1210	210		
33	Pettit	24	116	5.4	930	70		
34	Wells	21	125	5.3	1160	160		
35	Kenny	27	135	5.6½	1140	140		
36	Stocker	26	126	5.8	1080	80		
37	Seward	23	131	5.6	1060	60		
38	Johnson	29	135	5.9	1030	30		
39	Sargent	41	110	5.1	870	130		
40	Hasselant	32	192	6.1	870	130	29	
					42,850	5390	15	

No. of Mn.	Name	Age	Weight	Height	Res: 42850	Aggregation from 1000 5390	No between 900 & 1100 25
41	Holewell	21	150	5.10	1970	970	
42	Atwood	26	141	5.10	920	80	
43	English	34	131	5.7	890	110	
44	Nehringer	26	139	5.9	1280	480	
45	Butler	24	137	5.8	790	210	
46	Duffy	27	125	5.7	1120	120	
47	Sofie	17	97	5.6	1210	210	
48	Ferrel	19	132	5.9	1060	60	
49	Adye	30	127	5.10	1000	0	
50	Fohnlein	34	127	5.7	950	50	
51	Ward	11	68	5.1	1150	150	
52	Flinn	17	96	5.2	1030	30	
53	Jones	16	103	5.3	960	40	
54	McLaughlin	18	117	5.7	1000	0	
55	Bennett	19	130	5.9	1010	10	
56	Kennedy	17	120	5.8	960	40	
57	Condit	15	93	5.1½	1040	40	
58	Burnes	22	127	5.9½	950	50	
59	Neary	18	129	5.8	870	130	
60	Kingsbury	25	134	5.8	1030	30	
61	Wheeler	25	122	5.9½	760	240	
62	Riker	15	121	5.8	1150	150	
63	Gibbons	32	165	5.6	850	150	
64	Walter	19	106	5.6½	1100	100	
65	Dainty	34	145	5.7½	860	140	
66	Henderson	25	153	5.7½	850	150	
67	Sloane	27	139	5.5	890	110	
68	Agin	15	75	4.11	1500	500	
69	Markwith	20	121	5.4	1150	150	
70	Gray	30	124	5.7	1010	10	
71	Wright	26	150	5.11	1100	100	
72	Gallagher	27	159	5.9	990	10	
73	Kihen	21	135	5.7	750	250	
74	Jennings	22	106	5.6	1020	20	
75	Rogan	21	135	5.8	1010	10	
76	Belingi	25	135	5.7	1130	130	
77	Nenninger	27	129	5.8	1190	190	
78	Ferguson	23	126	5.8½	1280	280	
79	Smith Jr.	43	191	5.10	950	50	
80	Pfaff	32	158	5.5½	720	270	
81	Kolgin	22	152	5.9½	1000	0	
82	Nolge	20	144	5.7	1120	120	
83	Dudley	32	119	5.6½	1100	100	
84	Kleffel	36	174	5.8	810	190	
85	Dibble	24	129	5.4½	1020	20	
86	Pack	24	133	5.10¾	900	100	
87	Studer	30	144	5.4	750	250	
88	Stroebing	36	145	5.6	830	170	
89	Weldon	26	178	5.11	780	220	
90	Schindler	23	141	5.6	870	130	
91	Cooth	37	130	5.9	1040	40	
92	Luhr	18	130	5.9½	1070	70	
93	Friel	22	136	5.9	850	150	
94	Rettig	20	113	5.8	940	60	
95	Wolfing	29	162	5.6½	660	340	
96	Renyhan	25	135	5.7	930	70	
97	Schaffleinger	27	144	5.8	800	200	
98	Iplinger	39	130	5.6	770	230	
99	Mack	21	137	5.6	870	130	
100	Young	23	150	5.7½	870	130	
					102490	13930	42

No. of Ch.	Name	Age	Weight	Height	Res.	Expiration Forced 1000	Nebulosum 900 + 100
				' "	102490	1930	62
101	Zoller	39	136	5·8	840	160	
102	Becker	19	124	5·4	870	130	
103	Rymer	21	112	5·5½	1010	10	
104	Alley	21	121	5·7¼	1060	60	
105	Hammond	25	160	5·7	920	80	
106	Graham	22	145	5·11½	990	10	
107	Meyer	33	143	5·3	780	220	
108	Bulkhalle	22	160	5·9	750	250	
109	Jacobs	21	125	5·8½	950	50	
110	Kototzky	29	151	5·5½	900	100	
111	Mc Intosh	26	134	5·7	910	90	
112	Vaughan	23	170	5·7½	740	260	
113	Fulton	24	178	6·1	870	130	
114	Pitten	23	114	5·6½	1060	60	
115	Fuchs	25	160	6·1	1060	60	
116	Titus	34	160	5·5	830	170	
117	Snider	29	143	5·5	820	180	
118	Spies	48	122	5·10½	770	230	
119	Sherman	20	148	5·9½	850	150	
120	Dielenbacher	19	134	5·5	1000	0	
121	Aldat	19	109	5·4	940	60	
122	Aliffh	32	122	5·4	780	220	
123	Gordan	16	123	5·7½	1270	270	
124	Gannon	28	112	5·4½	950	50	
125	Thorpe	22	136	5·8½	820	180	
126	Schwab	17	115	5·2	950	50	
127	Edwards	18	120	5·7	1180	180	
128	Dickerson	16	118	5·9½	1010	10	
129	Howard	17	111	5·5½	1450	450	
130	Flinn	21	147	5·7	1040	40	
131	Barnard	21	140	5·6	850	150	
132	Hammer	28	149	5·8½	840	140	
133	Jordan	14	69	4·10	1650	350	
134	Mafey	25	133	6·0	1100	100	
135	Kane	19	119	5·6	1050	50	
136	Withey	33	144	5·7	1000	0	
137	Gerry	16	110	5·6½	920	80	
138	Young	26	144	6·0	1000	0	
139	Bishop	19	129	5·10	1320	320	
140	Schreiber	30	185	5·10½	750	250	
141	Attenhaus	22	192	5·10	870	120	
142	Kolb	31	150	5·7	980	20	
143	Mc Elroy	35	164½	5·9	840	160	
144	Savage	36	183	5·7	810	190	
145	Keenan	27	125	5·8	1020	20	
146	Chandler	38	154	5·10½	970	30	
147	Pierson	22	125	5·6½	1080	80	
148	Rotfearn	15	103	5·5	1070	70	
149	Weitz	40	186	5·10	820	180	
150	Howatt	20	138	5·9½	1050	50	
151	Ritz	27	176	5·10½	930	70	
152	Aymer	32	179	5·10	860	140	
153	Kearney	35	134	5·4	940	60	
154	Bradley	23	158	5·11	1000	0	
155	Kolb	30	166	5·3	1280	280	
156	Kinghorn	25	171	5·10	950	50	
157	Fitzgerald	28	148	5·7½	1050	50	
158	Shay	36	119	5·5	880	120	
159	Beck	21	133	5·4½	1100	100	
160	Harper	26	102½	5·2½	1050	50	33
					160910	28150	95

No. of Obs	Name	Age	Weight	Height	Rec.	Variation from 1000	No between 900 & 1100 yes
					160910	21170	
161	Conolly	18	117	5·6	1090	90	
162	Hutchinson	30	124	5·6½	830	170	
163	Littell	14	81	5·1	1290	290	
164	Spencer	28	120	5·5½	1050	50	
165	Nolans	20	158	5·11	850	150	
166	Mack	39	154	5·7½	850	150	
167	Wald	17	128	5·8	1050	50	
168	Hooper	22	131	5·8	990	10	
169	Kitchell	21	124	5·7	1130	130	
170	Oran	25	132	5·9	1000	0	
171	Byrnes	35	129	5·10	840	160	
172	Lanzet	39	139	5·8	950	50	
173	Marshat	26	140	5·9	850	150	
174	Farnham	22	153	5·10	860	140	
175	Bennett	24	131	5·4½	1020	20	
176	Hessdorfer	33	119	5·6	910	90	
177	Gamble	27	120	5·5½	960	40	
178	Forster	21	125	5·8	920	80	
179	Taney	39	125	5·6	930	70	
180	Riell	26	149	5·11	950	50	
181	Devine	18	103	5·1	1330	330	
182	Greer	19	145	5·9½	1420	420	
183	Ohaus	19	144	5·9½	1150	150	
184	Goodwin	19	109	5·2	930	70	
185	Vannees	23	126	5·5	1180	180	
186	Winter	32	132	5·6	1030	30	
187	Hall	33	137	5·10	1050	50	
188	Dalrymple	22	132	5·8	1300	300	
189	Kidd	28	109½	5·6½	850	150	
190	Hawes	26	124	5·7	1170	170	
191	Edge	27	133	5·6½	1030	30	
192	Mortimer	18	116	5·5½	1050	50	
193	Burke	21	130	5·7	940	60	
194	Martin	25	144	5·10½	930	70	
195	Lyon	17	122	5·6½	880	120	
196	Hagan	42	161	5·6	900	100	
197	Hefron	19	116	5·5½	1000	0	
198	Barker	21	159	5·9	770	230	
199	Cutter	45	143	5·5½	850	150	
200	Haney	25	130	5·10	1000	0	
201	Grove	18	110	5·4½	1200	200	
202	Hayden	30	130	5·10½	820	180	
203	Knight	28	127	5·8	1170	170	
204	Schuan	32	128	5·5	830	170	
205	Daly	30	130	5·6½	950	50	
206	Holmbie	18	176	6·0½	1000	0	
207	Hamell	21	143	5·11	1050	50	
208	Welch	20	138	5·7½	880	120	
209	Higginbotham	16	109	5·4	1030	30	
210	Hillmett	39	113	5·7½	1010	10	
211	Rosel	17	124	5·7	1050	50	
212	McCundy	30	147	5·7	1100	100	
213	Blauan	24	142	5·11	670	330	
214	Alford	33	177	6·0	940	60	
215	Stewart	25	154	5·6	910	90	
216	Richard	46	150	5·9½	950	50	
217	Corby	33	186	5·11½	820	180	
218	Lawler	26	152	5·9	890	110	
219	Jacobsen	28	148	5·9	850	150	
220	Kreelicher	39	146	5·5	930	70	33
					220,140	2,140 20	128
	$\frac{220,140 + 38,310}{229} = 986$			Mean	10005	127	

Physiological Experiments

Resumé of results.

The number of cases tested in the Laboratory was 39
- - - - - - Factory - 220
- total - - - 259

The mean resistance of the Laboratory men 905 ω
- - - - Factory - 1000.5 ω
- - - - both 986 ω

Taken all together the results were

Between	500 ω	and	600 ω	2	cases
-	600 ω	-	700 ω	9	- 3
-	700 ω	-	800 ω	17	- 4
-	800 ω	-	900 ω	35	- 47
-	900 ω	-	1000 ω	53	- 47
-	1000 ω	-	1100 ω	69	- 60
-	1100 ω	-	1200 ω	20	- 28
-	1200 ω	-	1300 ω	9	- 8
-	1300 ω	-	1400 ω	5	- 4
-	1400 ω	-	1500 ω	5	- 4
-	1500 ω	-	1600 ω	3	- 3
-	1600 ω	-	1700 ω	1	- 1
-	1700 -	-	1800 ω	0	- 0
-	1800 -	-	1900 ω	0	- 0
-	1900 -	-	2000 ω	1	- 1
				259	220

Taking the factory results $\Sigma v = 27920$

$\frac{0.81453\ \Sigma v}{\sqrt{220 \times 219}} = 107.6\ \omega$

that is to say by the theory of errors half the cases should fall within 107.6 ω of 1000 or from 893 to 1107 and as a fact 113 (111) could fall between 900 and 1100.

$\frac{0.81453\ \Sigma v}{220\ \sqrt{219}} = 7.25$

$h = \frac{0.6769}{10\ 7.25} = 0.0\cancel{6}\cancel{4}\cancel{4}93$

					Theoretical	actual
$x = 100$	$hx = 0.0\cancel{4}\cancel{4}93$		$y = 0.1469$	103.	103	107
$x = 200$	-	$= 0.8866$	$y = 0.790$	174	71	75
$x = 300$	-	$= 1.3299$	$y = 0.940$	207	33	22
$x = 400$	-	$= 1.7732$	$y = 0.988$	217	10	7
$x = 500$	-	$= 2.2165$	$y = 0.998$	219.5	2.5	4
$x = 600$	-	$= 2.65$	$y = 0.999$	220	0.5	4
						3
						1

The theoretical distribution of the variations on the theory of errors thus agrees fairly with the observed distribution.

Range	Number	x	hx	y	ε	d	obd.	d	obd
0 - 50	47	50	0.22.16	0.2459	54.8	54	47		
50 - 100	56	100	0.44.33	0.4693	103	49	~~[illegible]~~ 56	103	103
100 - 150	~~38~~	150	0.66.49	0.6531	144	41	38		
150 - 200	40	200	0.8866	0.7900	174	30	~~33~~ 40	71	78
200 - 250	13	250	1.1081	0.8826	194	20	13		
250 - 300	10	300	1.3300	0.9400	207	13	10	33	23
300 - 350	7	350	1.5516	0.9722	214	7	7		
350 - 400	1	400	1.7732	0.988	217	3	1	10	8
400 - 500	~~3~~ 4	500	2.2165	0.998	219.6	2.6	4	2.6	4
~~500 - 600~~	~~3~~	600	2.65	0.9999	220	0.4	4	0.4	4
over	~~4~~ 4	∞							

Physiological Experiments.

July 20th Saturday

Tested the resistance offered by a man's body under the following conditions. Two half jars containing KHO solution density 1.10 were employed with the usual copper plates. The EMF was 4 Fuller cells (8 volts) a res: and the Einhoff galvo were inserted between the bridge and battery so as to adjust the current. The following results were then obtained in m: f.z.

No. Obs.	Milliamp. Res. 6	Res. obt.	Milliamp. Res. patient	E.M.F. on patient	Impression	Mean.	Area of skin in sq. cm.	Res: of sq. cm. skin	Res: of body	Error of mean obs.
1	0.6	510ω	0.3	0.15 volt	3½" above ulnar condyle					
2	6.0	510ω	3.0	1.5						
3	6.0	620ω	3.0	1.9	ulnar condyle					
4	5.5	785ω	2.75	2.0	3rd phalanx middle finger					
5	5.0	925ω	2.5	2.3	2nd phal.					
6	4.5	1020	2.25	2.3	1st do.	1020	4B	54,200ω	4.20ω	± 40ω.
7		965			2nd "	940	150			
8		815			3rd do	800	370			
9		635			ulnar condyle	627	730			
11		475			3½" above wrist	497	900			

The girth at the condyle was 7" = 17.8 cms
- - - - point 3½" above - 8" = 20.3 cms
Mean 19.0 - × 3.5 × 2.54 = 169 sq. cm.

Took a pair of white kid gloves; put them on the hands and marked off roughly the lines corresponding to the above measures. Then weighed the gloves, the sections cut off between these lines and a plane measured area as follows.

Glove no 1

Portions	Observed weight	Weight per sq. cm.	Area	Total
Tips	1.035		46.2	
1-2 Phals.	2.350		104.9	151.1
2-3 Phals	4.855		216.7	367.8
3- Condyle	7.795		348.0	715.8
	16.035		715.8	
Wt. whole glove	16.040			
Wt. of palm	0.045	0.0224		

Glove no 2

Portions	Observed weights	Weight per sq. cm	Area	Totals
Tips	0.880	40.0	40.0	
1-2 Phal.	2.335	106.7	106.1	146.1
2-3 "	4.800	218.2	218.2	364.3
3- Condyle	8.265	375.7	375.7	740.0
	16.280		740.0	
Wt. whole glove	16.220			
Wt. of 10×13 cm	2.865	0.0220		

Mean values are in To tips 1st Phalanges 43.1 say 43
2nd " 148.6 149
3rd " 366.1 366
Condyle 728. 728
3½" Wrist 897 900

Physiological Experiments.

With the results at the foot of the last page we have

Where x is the res: per unit surface of skin and y half the interior res: of the body.

$$\frac{x}{43} + y = 510 \quad (1)$$
$$\frac{x}{150} + y = 470 \quad (2)$$
$$\frac{x}{370} + y = 400 \quad (3)$$
$$\frac{x}{730} + y = 313.5 \quad (4)$$
$$\frac{x}{900} + y = 246 \quad (5)$$

$$x + 43y = 21930 \quad (6)$$
$$x + 150y = 70500 \quad (7)$$
$$x + 370y = 148000 \quad (8)$$
$$x + 730y = 228800 \quad (9)$$
$$x + 900y = 221400 \quad (10)$$
$$5x + 2193y = 690630 \quad (11)$$

$$43x + 1849y = 942990 \quad (12)$$
$$150x + 22500y = 105750000 \quad (13)$$
$$370x + 136900y = 54760000 \quad (14)$$
$$730x + 532900y = 167022400 \quad (15)$$
$$900x + 810000y = 199260000 \quad (16)$$
$$2193x + 1504149y = 432561990 \quad (17)$$

from (17) $\quad x = 197247 - 685.9y$

(11) $\quad 986235 - 3429.5y + 2193y = 690630$

$$1236.5y = 295605$$
$$y = 239.1 \quad (18)$$

$2y$ the res: of the body $= 478$ ω

$$x = 197247 - 163971$$
$$= 33276 \quad \text{say } 33300 \text{ ω} \quad (19)$$

$$774 + 23g = 1013 \qquad x - M = +503 \quad (20)$$
$$222 + 23g = 461 \qquad = -g \quad (21)$$
$$90 + 23g = 329 \qquad = -71 \quad (22)$$
$$46 + 23g = 285 \qquad = -28.5 \quad (23)$$
$$37 + 23g = 276 \qquad = +30 \quad (24)$$

$$v^2 = 25300g$$
$$81$$
$$50241$$
$$812$$
$$900$$
$$259,843$$

$\sqrt{\ } = 510 \times 0.3894 = 198.6 \pm$ as the error of one obs:

If however we omit equation (1) we have for the normal equation

$$42x + 21500y = 668700 \quad (25)$$
$$21500x + 1502300y = 431,619,000 \quad (26)$$

from (26) $\quad x = 200753 - 698.7y$

$$803012 - 279745y + 21500y = 668700$$
$$6244.8y = 135312 \qquad y = 209.8 \quad (27)$$
$$x = 200753 - 146587 = 54,166. \quad (28)$$

from (27)·(28)

$$361 + 210 = 571 \quad = +101 \qquad 10201 \qquad 58.5 \times 1.6745$$
$$146 + 210 = 356 \quad = -44 \qquad 1936 \quad = 39.5$$
$$74 + 210 = 284 \quad = -20 \qquad 900$$
$$60 + 210 = 270 \quad = +24 \qquad 576 \quad \text{mean error of each obs:}$$
$$\Sigma v^2 = 13613$$
$$\Sigma v = 117$$

$116,456g.r.0 + 315,182,540 = 431,639,440.$

On the winding of a large radial (Ore-Milling) Electric Magnet

Twenty radial slots of cast iron project from a cylinder of 25" (60 cm) external diameter. Each slot is 32" wide 6" deep and 2" thick; separated at the surface of the cylinder by a distance of 1¾". Required the most effective winding.

Let d be the diam. of the conductor
ρ - its resistivity
t - its covering thickness
k - the ailing space
a - - length of each turn (average)
l - - total length of wire on each slab
c - - current
E - - emf in each slab.
n - no. of turns

Then $l = \dfrac{k}{(d+t)^2}$

$n = \dfrac{l}{a} = \dfrac{k}{a(d+t)^2}$

ampere turns $= \dfrac{cl}{a} = \dfrac{ck}{a(d+t)^2}$

but $c = \dfrac{E}{\frac{4l\rho}{\pi d^2}} = \dfrac{E\pi d^2}{4l\rho} = \dfrac{E\pi d^2(d+t)^2}{4\rho k}$

$\therefore$ ampere turns $= \dfrac{E\pi d^2}{4a\rho}$ which increases indefinitely with d.

The limit is found in the heating of the wire

Suppose the current limit to be 10 amperes, and suppose each quadrant of 5 slabs to be joined in parallel then the p.d. on each slab will be $\frac{100}{5} = 20$ volts and the res. $= 2\,\omega$.

$$\therefore \frac{k}{(d+t)^2} \times \frac{4\rho}{\pi d^2} = 2\times 10^3$$

$$\pi(d+t)^2 d^2 = \frac{4\rho k}{2\,10^3}$$

$$(d+t)\,d = \sqrt{\left(\frac{4}{\pi}\frac{\rho k}{10^3}\right)}$$

$$d^2 + td + \frac{t^2}{4} = \frac{t^2}{4} + 10^{-3}\sqrt{\frac{\rho k}{5\pi}}$$

$$d = -\frac{t}{2} \pm \sqrt{\left\{\frac{t^2}{4} + 10^{-3}\sqrt{\frac{\rho k}{5\pi}}\right\}}$$

Here t is 0·02
ρ is 1600
k is $311 \times 16\cdot 2g = 5000$ $\quad (0\cdot 75'' \times 6g \times 6) = 311$

$\dfrac{\rho k}{5\pi} = \dfrac{5000{,}000}{15708} = 5094{,}400$ $\quad \sqrt{\ } = 7114 \times 10^{-4} = 0\cdot 07114$
$= \dfrac{0\cdot 0004}{0\cdot 07148} = 7\cdot 18 \times 10^{-2}$

$t^2 = 4\cdot 0 \times 10^{-4}$ $\quad \sqrt{\ } = 2\cdot 68 \times 10^{-1}$

$d = 0\cdot 2268 - 0\cdot 01 = 0\cdot 2258$ cm $= 0\cdot 102''$
$=$ midway between 12 + 13 wire B.W.G.

Let us take # 12 which is 0·109" + covered 0·117".

$(0\cdot 117)^2 = 0\cdot 01369$

$\dfrac{300}{0\cdot 01369} = \dfrac{3\cdot 0 \times 10^2}{1369 \times 10^{-4}} = 2\cdot 19 \times 10^4$ inches $= 1\cdot 83 \times 10^3$ feet 1830

$8\cdot 69 \times 10^{-4} \times 1\cdot 83 \times 10^3 = 1\cdot 59 \times 10^{-1} = 1\cdot 6\,\omega$.
$1\cdot 83 \times 10^3 \times 3\cdot 60 \times 10^{-4} = 6\cdot 59 \times 10^{-1} = 65\cdot 9$ lbs say 66 lbs per slab
$= 1320$ lbs of # 12 wire in all.

Physiological Experiments.

To ascertain the amount of heat generated by a given current beyond dispute, for presentation to the electrocide commission took a glass tube 175 cms long and 4·8 cms internal diam. Passed a wire carrying a zinc disk electrode watertight through a rubber stopper and filled the tube to within a few cms of the top with 5 lbs 7 ozs = 2495 grammes of $ZnSO_4$ solution density 1·012 = 2466 c.c. A zinc leclanché rod was plunged into the solution for about 8 cms at the top. The res. of this vertical column was observed to be 119·5Ω @ 25°C. A standard thermometer was suspended with its bulb half way down the tube.

The 1200 volt dynamo was connected up with the tube at 4 o'clock through the Ayrton galvanometer. The P.D. on the tube was observed by potentiometer to be

$$\frac{1{\cdot}426 \times 200{\cdot}218}{218} = 1310$$

the current should have been $\frac{1310}{1195} = 1{\cdot}096$ ampères.

It was observed to be $\frac{0{\cdot}22}{0{\cdot}195} = 1{\cdot}128$ ampère.

The current was applied for sixty second.

At the end of that time the Ayrton reading was 0·224 = 1·23 amp

and the p.d. $\frac{1{\cdot}426 \times 200{\cdot}224}{224} = 1275$ volts

The observed resistance was 1040Ω so that the final current strength should have been by calculation 1275/1040 = 1·226

The mean strength of current was 1·18 ampères.

" p.d. 1293 volts

" energy developed in the tube was 1293 × 1·18 × 60 = 91560 Joules

= 21800 thermes ÷ 2495 = 8·74° C rise assuming sp. heat of solution = 1·0 " The actual rise of temp. was to 33·0°C = 8·0°C.

Stretched 146·5 metres 151·6 feet of platinoid wire 0·011" up and down the galvanometer room. Checked the Cardew voltmeter by setting it across the 112 volt mains = 181°. Voltmeter indication on alternating electrodes = 112° = 95 − 9·5 = 85·5 volts. Set two jars of caustic potash solution one at one end of the fine wire and the other on a movable contact. Found that 2·2 metres was all I could fairly stand without inconvenience. Lehmann took about 3·2 metres. These voltages are $\frac{2{\cdot}2 \times 85{\cdot}5}{146{\cdot}5}$ and $\frac{3{\cdot}2 \times 85{\cdot}5}{146{\cdot}5}$ = 4·0145 and 5·885

Particulars of the new phonograph governor shunt.

Length 28" = 71·5 cms platinoid wire 0·018" diam. res: 1·65Ω

Physiological Experiment.

Took a series of resistances of five men under certain conditions as follows:- Two # 11 B.W.G wire 0·12" diam were connected with the Wheatstone Bridge terminals. The extremities were bared for 6 inches or so. A sheet of tinned iron 20" × 20" was also provided. The routine was as follows. Each man

1st (a) held the wire between finger thumb of each hand (dry) as lightly as he could

(b) held the wire in his hand lightly

(c) grasped the wire tightly.

2nd (a) (b) + (c) with wetted hands.

3rd (a) (b) + (c) were repeated with strips of sheet zinc in place of the wires of the last experiment. These strips were 8" long and 1½" wide. The hands dried

4th (a) (b) + (c) with the same strips but the hands wetted.

5th (a) (b) + (c) with the wire in one hand (dry) and standing in boots on the dry plate, itself on the dry floor. Day has been dry though weather humid.

6th (a) (b) + c with the hand wetted.

7th The resistance between the hand immersed in jar of tap water up to the wrist with the above zinc plates as electrodes

8 volts 1000 mm f.2

Set	Holding	Conditions Hands			Lehmann	Hipple	Hayes	Fred.	Batchelor	
						Names				
1	Wires	dry	touching wire		100,000	130,000	200,000	92,000	400,000	
			grasping wire		80,000	36,000	170,000	50,000	200,000	
			clutching "		25,000	25,000	60,000	44,000	70,000	
2		wet	touching "		16,000	30,000	50,000	50,000	40,000	
			grasping "		14,000	13,000	25,000	35,000	16,000	
			clutching "		6,300	9,000	17,000	21,000	13,000	
3	Strips	dry	touching strip		75,000	100,000	160,000	50,000	200,000	
			grasping "		25,000	33,000	77,000	44,000	80,000	
			clutching "		6,000	10,000	37,000	11,700	21,000	
4		wet	touching "		10,000	33,000	55,000	32,000	100,000	
			grasping "		6,000	21,000	30,000	28,000	14,000	
			clutching "		2,700	7,000	16,000	8,000	9,000	
5	Standing on plate with one hand	dry	touching wire		32,000	68,000	110,000	55,000	200,000	
			grasping "		26,000	35,000	100,000	35,000	80,000	
			clutching "		16,000	18,000	49,000	20,000	60,000	
6		wet	touching "			23,000	50,000	32,000	60,000	
			grasping "			22,000	38,000	28,000	40,000	
			clutching "			8,000	16,000	14,000	35,000	
7			Res. of body between hand immersed in plain water.			2550	2700	2250	2650	

The only reasonable assumption appears to be that there were originally 3 circuits on the Bechtelville magnet each 90 lbs of #12 B.S. 0.081" having a res. of 0.08 w per lb = 7.02 w
÷ 3 = 2.4
two circuits above this each of 145 lbs #12 B.W.G 0.109" = 0.024 = 3.145
÷ 2 = 1.74
Total 4.14 w

90 lbs of #12 B.S. @ 50 ft per lb	= 4500 feet.	= 340 turns × 8.67	=	2960 AT
90 " " "	"	"		2960
90 " " "	"	"		2960
145 " " B.W.G. @ 27.8 " "	4060 "	= 308 × 13	=	4000
145 " " "	"	= 205 × 13	=	4000

The Watts generated @ 26 amp = 2860 = 680 therms per sec. 16880 AT
The surface of the magnet is 25.2 sq. ft. = 23400 sq cms.
= 0.129 Watts per sq. cm. = 0.029 therms per sq. cm.
This is excessive. Suppose that there should be not more than 0.014 therms to the sq. cm: = abt 18 amperes in this case.
The new magnet should therefore have say 25000 ampere turns at this surface rate of heat dissipation.
The surface is 7.5 × 1.75' = 13.12 sq ft = 12,200 sq. cms
12200 × 0.014 = 1.22 × 1.4 × 10^2 = 170.7 therms per sec.
= 717 Joules per sec.
= 6.5 amperes.

25000 ÷ 6.5 = 3846 turns = 3846 × 7.5 = 28,840 feet
110 ÷ 6.5 say ÷ 7 = 15.6 w = 1850 feet per w = #10 B.W.G.
1850 × 0.054 = 998 lbs. altogether too expensive.

Taking 20,000 ampere turns and 0.020 therms.
= 2.44 therms per sec
= 1025 Watts
= 9.31 amperes.

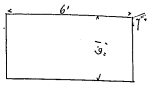
20,000 ÷ 9.31 = 2150 turns = 2150 × 7.5 = 16120 feet
110 ÷ 9.5 = 11.58 w = 1392 feet per w
= #11 B.W.G.
16120 × 0.0436 = 703 lbs. wire.
say 700 lbs of #11 B.W.G.

Check 700 × 0.0164 = 11.48 w @ 110 volts say 12 w = 9.18 amperes.
700 × 22.94 = 16,058 feet ÷ 7.5 = 2140 turns = 19,660 A.T.
110 × 9.18 = 1009.8 say 1010 Watts = 240.6 therms
= 2.406 × 10^2 ÷ 1.22 × 10^4 =
nearly 2.0 × 10^-2 = 0.02 therms per □
= 0.084 Watts per sq. cm.

Allowing 0.1 Watts per cm = 1220 Watts = 11.1 amperes = 10 w.
20,000 ÷ 11.1 = 1800 turns = 13,500 feet = 1350 ft per w = #11 wire 0.4
13500 × 0.0436 = 589 lbs. say 600 lbs of #11 B.W.G.

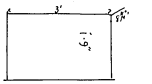
On the winding of an Ore Milling Magnet for Gilbert's mine Bechtelville Pa.

The previous magnet had it is stated 500 lbs. of #13 ? B.W.G. wire. The dimensions were as shown.



One turn would be 13' 2" = 13.17'
= 13.17 × 2.73 × 10^-2 lbs = 0.36 lbs.
so that there would be 500/0.36 = 1390 Turns
say 1400 or 26 × 1400 = 35000 A.T.
140/26 = 4.08 w 500 lbs of #13 = 214 w
#14 = 36

The new magnet is to have the following dimensions so that one turn will have a length of 7.5 feet. The current to be 20 amperes on 120 volts = 6 w.



#13 wire = 4.187 w × 10^-2 per lb
600/4.187

The Ore Milling Magnet at work in the laboratory allows 23 amperes to flow through it from the 110 volt cct or has a res. of 4.78 w at starting = 19.12 w in all. There being two circuits. 23.88 × 19.12 = 456 lbs. of wire.
The current strength is thus 9025/23 = 390 c.m. per ampere.

The ore milling magnet at Bechtelville has it is said 500 lbs of wire on it, to which 126 has lately been added. The current commenced at 26 amp. but fell with time to twenty. Supposing it also to have two cct this would be 13 amp. @ 110 volts = 110/13 = 8.46 w × 2 = 16.92 w in all. 126 lbs have a res. of 4.19 × 1.26 = 5.28 w. If the previous 500 were in 2 cct:
= 4.23 w. 4.23 + 2.64 = 6.87 w. 110/6.87 = 16.0 amperes.

By letter of 27th July from Mr Kreuzi the ore milling magnet at Bechtelville has

1st section of 3 layers	#12 B.S.	27 volts	0.081" = 0.073 w per lb	= 19.71 w
2nd " " 3 "	#12 B.W.G.	29 "	0.109 = 0.024 w "	= 7.02 w
			Phoenix Total res:	26.73 w
3rd " " 2 "	#13 B.W.G.	127	0.095 = 0.0419 "	= 5.32
			Total present res.	32.05 w

at 120 volts 26 amp = 4.23 w.
9.85 × 7.02 / 16.87 = 4.10 7.02 × 19.7 / 26.7 = 5.18 × 26 = 134.7
13.84 ×

The Laboratory ore milling magnet having a surface of about 23,000 sq. cms and taking 23 × 110 = 2530 Watts = 0.11 Watt per sq.

Meter Experiment

by Mr C. West 25th July 1889.

One lamp in cct with a 100 light bottle for 45 mins: Current on lamp 0.34 amp × 1224 × 0.75 = 312 mgms. Actual gain 320 mgms on gain plate 320 and plate not perfectly dried.

Test of New Standard Meter Shunt.

26th July 1889 Friday.

A current from the 5 volt machine was passed through the new standard meter strip and also through the standard legal ohm, whose electrodes were reamalgamated and which stood in a jar of water. The differential method was employed.

The res: of both coils was 5425ω @ 25·3° C T.B.

1st trial 4532ω added to 1ω cct. Temp. of water inside legal ohm 25°

Res: of legal ohm at this temp = 28-15·5 = 12·5 × ·03 = ·375 = 1·00375

2712 + 4532 : 2712 :: 1·00375 : x

$$x = \left(\frac{7244}{1.00375 \times 2712}\right)^{-1} = 0.3758\omega$$

2nd trial 4514ω added to 1ω cct Temp water 23°C

Res of legal ohm = 23 − 15·5 = 7·5 × 0·03 ·225 = 1·00225

2712 + 4514 : 2712 :: 1·00225 : x

$$x = \frac{1.00225 \times 2712}{7226} = 0.3763\omega$$

3rd trial 4509ω added to 1ω cct. Temp. water 23°C

Res: legal ohm = 1·00225

2712 + 4509 : 2712 :: 1·00225 : x

$$x = \frac{1.00225 \times 2712}{7221} = 0.3765$$

4th trial 4509ω added to 1ω cct. Temp water 22°C

Res: legal ohm = 1·00195

2712 + 4509 : 2712 :: 1·00195 : x

$$x = \frac{1.00195 \times 2712}{7221} = 0.3764\omega$$

Temp: of air in meter box 23·3°C.

Res: of both galvo: coils after test 5425ω as before + 4509ω = 4508ω T.B. 3.7

Accepted result of test = 0·3764ω @ 23·3°C.

Taking the electrochemical equivalent of zinc per ampere hour as 1.224 we have 1223 × 0·3764 = 460·3 − 2·3 if res: of bottle be taken as 2·3 leaves 458ω as the res: required in the spool in order that one milligramme transfer shall represent the ampere-hour.

On the Power Required to Decompose 25 gallons of water per min.

One ampère decomposes 9.324×10^{-5} gms per sec:

1 gallon = 8 lbs

25 - " " 200 -

1 lb = 454 gms

200 - = 90800 gms = 9.08×10^{4}

$$\frac{90.80 \times 10^{4}}{9.324} = 9.74 \times 10^{3} \text{ ampères} \div 60 = 1.62 \times 10^{2}$$

$$9.74 \times 10^{3} \times 3 = 28.22 \times 10^{3} \text{ watts.}$$

$$\frac{2822}{746} \times 10^{6} = \frac{3.784}{60} \times 10^{4} \text{ H.P.} = 6.3 \times 10^{4} \text{ HP} = 63000$$

Even allowing only 2 volts as necessary it would still mean 42,000 HP.

In a letter of the 26th January, 1890 a gentleman in Buenos Aires Mr Fr Reynaud, asks Mr Edison how much power would be needed to electrolyze 6000 cubic feet of hydrogen per hour.

6000 c.f. per hr. = 100 c.f. per min = 1.667 c.f. per sec:

1 c.f. = 28316 c.c. ∴ 1.667 c.f. = 47,200 c.c.

11316 c.c. H. weigh 1 gm ∴ 1.667 c.f. of H. weigh 4.170 gms.

4.171 gms of H exist in 9×4.171 = 37.53 g gms. H_2O.

$$\text{Ampère required} = \frac{3.754 \times 10^{1}}{9.324 \times 10^{-5}} = 4.025 \times 10^{5}$$

At 2 volts emf = 8.05×10^{5} Watts

= 805 Kilowatts.

= 1094 chevaux vapeurs.

@ 90% eff = 900 klt or 1210 chevaux vapeurs

A coulomb liberates 1.038×10^{-5} grammes of hydrogen &

1 gm = 11316 c.c.

∴ 1 coulomb liberates $1.038 \times 1.1316 \times 10^{-1}$ = 0.1174 c.c.

∴ 1 ampère develops in one second 0.1174 cc.

" " " " minute 7.044 cc.

" " " " hour 426 cc.

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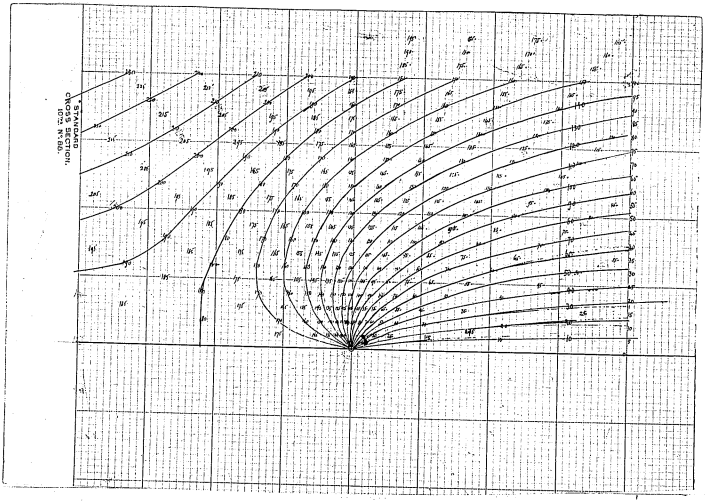

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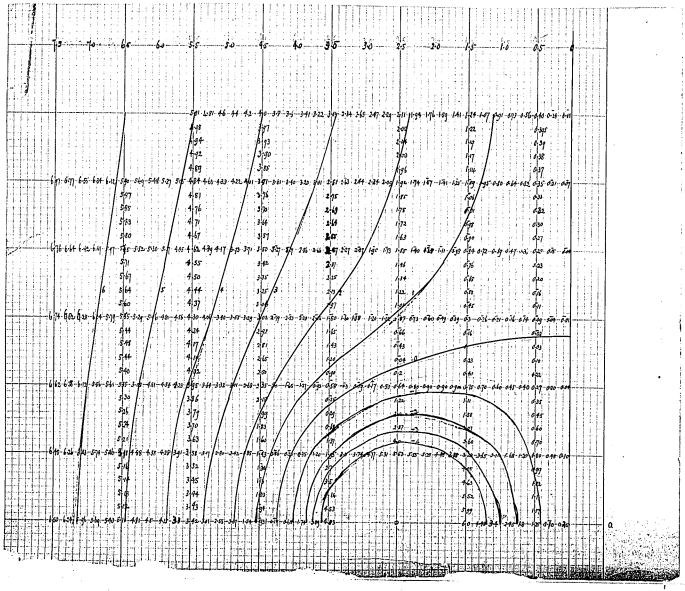
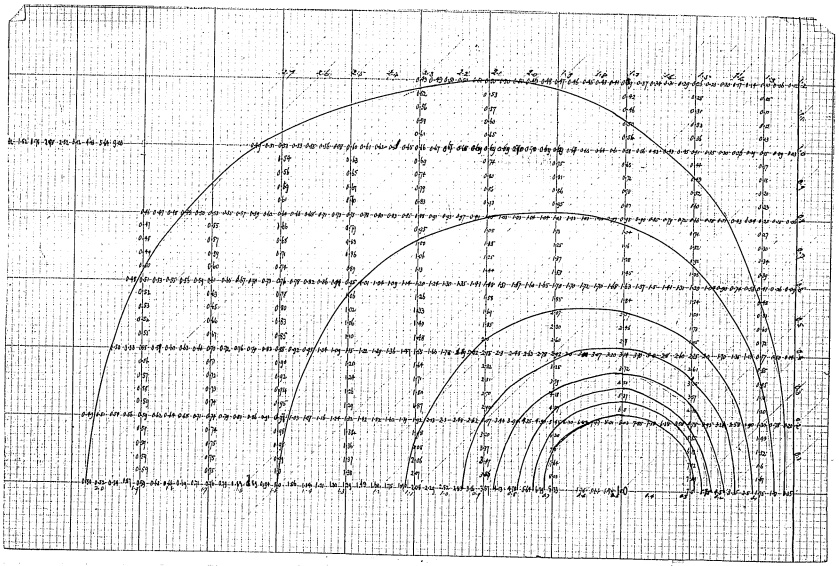
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